MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY

Vol. 94 No. 4

1934 FEBRUARY 9

ANNUAL GENERAL MEETING

Prof. F. J. M. Stratton, President, in the Chair.

The Minutes of the preceding Annual General Meeting were read and confirmed.

The President announced that Dr. Harlow Shapley would deliver the George Darwin Lecture at the Ordinary Meeting of the Society on May 11, taking as his subject "Some Structural Features of the Metagalaxy."

The Report of the Auditors of the Treasurer's accounts for the year 1933 was read, and is given on p. 269.

The Annual Report of the Council was partly read.

The President referred to the recent death of Professor Julius Bauschinger, an Associate of the Society.

The President delivered an Address on "International Co-operation in Astronomy: A Chapter of Astronomical History" (see p. 361).

The President having appointed the Scrutineers, the Society proceeded to the ballot for Officers and Council for the ensuing year. The names of those elected are given on p. 373.

Dr. Steavenson showed lantern slides which have been added to the Society's collection during the past year.

Dr. Spencer Jones described the progress of the work on the determination of the solar parallax from observations of Eros during the opposition 1930–31.

The thanks of the Meeting were given to the retiring members of Council, and also to the Auditors of the Treasurer's accounts and to the Scrutineers of the ballot.

The election by the Council of the following Fellows was duly confirmed :—

Raymond Arthur Lyttleton, B.A., Clare College, Cambridge ;
Vincent Oswald Woodfield Peters, Lieut., R.N.R., 36 Connought Road, Hong Kong, China ;
Somasundram Sabapathipillai, 112 Gower Street, London, W.C. 1 ;
Arthur Geoffrey Walker, B.A., Ph.D., Merton College, Oxford ; and
Donald Arthur Wright, B.Sc., 48 East Lane, North Wembley, Middlesex.

The following candidates were proposed for election as Fellows of the Society, the names of the proposers from personal knowledge being appended :—

Ernest Archibald Chamberlain, Royal Observatory, Greenwich, London, S.E. 10 (proposed by H. Spencer Jones) ;
Laurence E. Lefèvre, M.A., D.Phil., Eton College, Windsor (proposed by H. Dingle) ; and
Joseph Tetley, 10 Cumberland Road, Headingley, Leeds, 6 (proposed by R. Stoneley).

REPORT OF THE COUNCIL TO THE HUNDRED AND FOURTEENTH ANNUAL GENERAL MEETING OF THE SOCIETY.

PROGRESS AND PRESENT STATE OF THE SOCIETY

	Patron	Institutional Members	Honorary Member	Fellows		Associates	Total
				Compounders	Annual Subscribers		
1932 December 31	1	4	1	216	692	47	961
Since elected	...	...	...	+3	+38	+2	...
Deceased	...	...	...	−5	−10	−1	...
Resigned	...	...	...	...	−17	...	...
Since compounded	...	...	...	+7	− 7	...	...
Removed from list	...	...	...	...	−16	...	...
1933 December 31	1	4	1	221	680	48	955

(Six Associates are also Fellows, and are therefore counted twice in the above table.)

RECEIVED

	£ s. d.	£ s. d.
Balances, 1933 January 1 :—		
In hand of Assistant Secretary on Petty Cash Account	10 9 9	
At Bankers', on Current Account	189 14 10	
At Bankers', on "C" Account (Trust Funds)	116 7 0	
		316 11 7
Received on account of Dividends :—		
£1250 Metropolitan Consolidated 3% Stock	37 10 0	
£2000 Swansea Corporation 3½% Stock	70 0 0	
£2287, 6s. 9d. East Indian Railway 3% Debenture Stock	51 9 0	
£5125 London, Midland and Scottish Railway 4% Debenture Stock	153 15 0	
£750 London, Midland and Scottish Railway 4% Consolidated Preference Stock	16 17 6	
£2400 Gas Light & Coke Co. 3% Debenture Stock	54 0 0	
£2000 Commercial Gas Co. 3% Debenture Stock	45 0 0	
£1035 Agricultural Mortgage Corporation 4½% Debenture Stock, 1961–91	34 18 8	
£695, 16s. Conversion Loan 3½% Stock, 1961	24 7 0	
£419, 17s. 11d. Conversion Loan 4½% Stock, 1940–44	18 17 10	
£700 Birmingham Corporation 3% Inscribed Stock, 1947	18 7 6	
£496 Consolidated Loan 4%	17 7 1	
£2000 New Zealand 3½% Loan, 1940	61 5 0	
£1000 Hull Corporation 4½% Redeemable Stock, 1957–72	37 10 0	
£500 War Loan 3½% Inscribed Stock	17 10 0	
£500 New South Wales 4% Stock, 1942–62 (half-year's Dividend)	7 10 0	
£1000 Central Electricity Board 4½% Stock, 1957–82	31 17 6	
Interest on Deposit Account	0 10 7	
Income Tax refunded, 1932 April–1933 April	144 6 6	
	842 19 2	
Sales of Publications £310 10 10		
Reprints 77 11 6		
	388 2 4	
Sales of Photographs	52 12 6	
Miscellaneous Receipts :—		
London Mathematical Society, expenses of Meetings, etc. £30 0 0		
Assistant Secretary and Clerk, Pension Premiums ... 19 5 0		
Postages repaid 4 13 11		
Use of Telephone 0 5 3		
Sale of Baily's Portrait 0 10 0		
Sale of Waste Paper 0 3 3		
	54 17 5	
Royal Society, grant from Government Publications Grant, for *Geophysical Supplements*, 1933	50 0 0	
University of Michigan, donation	59 8 0	
		1447 19 5
Bequest from the late Archdeacon Potter		318 16 2
Received on account of Subscriptions :—		
555 Annual Contributions for 1933 (including 3 Institutional Membership fees)	1165 10 0	
27 Annual Contributions for 1934 in advance (including 1 Institutional Membership fee)	56 14 0	
41 Admission Fees	86 2 0	
38 First Contributions	78 15 0	
Arrears paid off :—		
13 for 1931 ... ... £27 6 0		
33 for 1932 ... ... 69 6 0		
	96 12 0	
		1483 13 0
Compositions (initial and reduced)		178 10 0
Trust Fund Dividends :—		
£1212, 13s. 3d. East Indian Railway 3% Debenture Stock	27 6 0	
£542, 18s. 2d. India 3½% Stock	19 0 0	
£965 Agricultural Mortgage Corporation 4½% Debenture Stock, 1961–91	32 11 6	
£1004 Consolidated Loan 4%	35 2 10	
Donation from General Fund (balance of George Darwin Lecture fee)	9 16 10	
Income Tax refunded, 1932 April–1933 April	24 10 10	
		148 8 0
		£3893 18 2

Examined and found correct.
(Signed) C. O. BARTRUM
D. H. SADLER

1934 *January* 18

ASTRONOMICAL SOCIETY, FROM 1933 JANUARY 1 TO DECEMBER 31

Account

PAID

	£ s. d.	£ s. d.
Assistant Secretary : Salary	250 0 0	
Clerk : Salary	175 0 0	
Assistant Secretary and Clerk, for work done for London Mathematical Society in 1932	10 0 0	
Pension Premiums, Assistant Secretary and Clerk	57 15 0	
Porter and Wife : Wages	153 16 6	
Health and Unemployment Insurance	6 18 8	
		653 10 2
Licence for Porter	0 15 0	
Fire and Accident Insurance	15 15 3	
Telephone	13 8 9	
Telegraphic Address	2 0 0	
Time Signal	5 2 8	
Water Rate	12 12 0	
		49 13 8
Postage and Packing (including postage of *Monthly Notices*, etc., £116, 18*s.* 2*d.*)		169 9 7
Printing, etc. :—		
Monthly Notices (Vol. **92,** No. 9 ; Vol. **93,** Nos. 1–9)	1039 11 6	
Geophysical Supplements (Vol. **3,** Nos. 3, 4)	59 6 2	
Memoirs (Vol. **65,** Part 2)	57 17 0	
Reprints	138 9 0	
List of Fellows, 1933	53 1 9	
Slide Catalogue	34 0 7	
Miscellaneous	64 7 0	
Photo-engraving	71 5 7	
		1517 18 7
Reproduction of Photographs for sale		67 14 9
Stationery and Office Expenses	33 5 7	
Library Equipment, Binding, Purchase of Books (General Fund)	63 16 1	
Subscription to International Telegrams Bureau	4 1 6	
Subscription to Committee on Library Co-operation	1 1 0	
Contribution to Wollaston Memorial	1 0 0	
Cabinet for Stock of Photographs for sale	10 10 0	
Coal, Gas, Electric Light, Firewood	95 5 7	
Fittings and Repairs	45 19 2	
Bathroom in basement (paid on account)	4 3 0	
House Expenses and Laundry	26 19 8	
Officers' Travelling Expenses	9 14 4	
Redecoration of Assistant Secretary's Sitting-room	11 1 0	
Office of Works, Establishment Charge on Re-wiring of Society's Premises, 1932	17 5 4	
Overhaul of five Speculum Mirrors	2 17 6	
Repair of Goodricke's Portrait	2 2 0	
Balance of George Darwin Lecture Fee	9 16 10	
Miscellaneous Expenditure	7 14 0	
Expenses of R.A.S. Meetings and Committees	17 3 5	
Expenses of Geophysical Meetings	4 15 7	
Expenses of L.M.S. Meetings	5 18 2	
Bank Charges and Cheque Books	3 2 8	
		377 12 5
		2835 19 2
Purchase of £300 War Loan 3½% Inscribed Stock (Potter Bequest)		301 1 0
Expenditure on Trust Accounts :—		
George Darwin Lecture Fee	50 0 0	
Turner and Horrocks Fund (Library)	16 9 11	
Harry Watson Fund (Library)	100 16 2	
		167 6 1
Balances, 1933 December 31 :—		
In hand of Assistant Secretary on Petty Cash Account	9 10 10	
At Bankers', on Current Account	464 17 0	
At Bankers', on " C " Account (Trust Funds) (including balance of Potter Bequest, £17, 15*s.* 2*d.*)	115 4 1	
		589 11 11
		£3893 18 2

Revenue

	£	s.	d.	£	s.	d.
To General Expenditure as per Cash Account	2835	19	2			
,, Reserve for Accounts due but not presented...	240	0	0			
	3075	19	2			
Less Reserve for Accounts due 1932 now written back ...	390	0	0			
				2685	19	2
,, Amount transferred to Composition Fees Reserve Fund in 1933...				178	10	0
,, 31 Annual Contributions in Arrear written off	65	2	0			
,, 1 Admission Fee and First Contribution, 1932, written off ...	4	4	0			
,, 18 Annual Contributions 1933 written off as per contra ...	37	16	0			
				107	2	0
,, Excess of Income over Expenditure, 1933				335	18	8
				£3307	9	10

Examined and found correct.

(Signed) C. O. BARTRUM
D. H. SADLER

1934 *January* 18

Account, 1933

		£	s.	d.	£	s.	d.
By Subscriptions—							
555	Annual Contributions 1933, including 3 Institutional Membership Fees	1165	10	0			
25	ditto paid in 1931 and 1932, now matured	52	10	0			
78	ditto, outstanding	163	16	0			
18	Contributions for 1933 due, but unpaid, in respect of Fellows died, resigned, or names removed, and written off per contra	37	16	0			
					1419	12	0
37	First Contributions, 1933, at 2 guineas	77	14	0			
1	ditto, at 1 guinea	1	1	0			
38					78	15	0
41	Admission Fees, 1933				86	2	0
3	Composition Fees at 30 guineas	94	10	0			
7	ditto, reduced	84	0	0			
10					178	10	0
	6% of Composition Fees Reserve Fund as per Balance Sheet, transferred to Current Revenue				39	16	9
	Sundry Debtors, 1933				40	7	0
	Dividends, Sales of Publications and Photographs, and Miscellaneous Receipts, as per Cash Account	1447	19	5			
Less	Payments due in 1932 (£8, 15*s.* 7*d.*, *less* 11*s.* 10*d.* still outstanding) £8 3 9						
Less	Advance payments for *Monthly Notices*, Vol. 94 43 17 9						
Less	Income Tax (General Fund) 1932 April–December, refunded in 1933 75 6 5						
		127	7	11			
					1320	11	6
	Payments for *Monthly Notices*, Vol. 93, received in 1932 and now matured				59	12	9
	Income Tax (General Fund) deducted at source 1933 April–December, not yet refunded				84	2	10
					£3307	9	10

Balance Sheet

LIABILITIES

	£ s. d.	£ s. d.
2 Subscriptions for 1934–35, paid in 1931	4 4 0	
1 Subscription for 1934, paid in 1932	2 2 0	
27 Subscriptions for 1934, paid in 1933	56 14 0	
		63 0 0
Sundry Creditors for Accounts due but not presented ...		240 0 0
Cash Balances (Income) of Trust Funds—		
Turnor and Horrocks Fund	5 1 4	
Harry Watson Fund	7 16 0	
Lee and Janson Fund	26 10 10	
Hannah Jackson Fund	37 19 2	
George Darwin Lectureship Fund	20 1 7	
		97 8 11
Trust Funds (Capital), as per contra		2964 0 0
Income Tax on Trust Funds, 1933 April–December, not yet refunded, as per contra		17 13 3
Special Fund (Capital), as per contra		1460 0 0
Composition Fees Reserve Fund—		
As at 1932 December 31	485 11 6	
Received in 1933	178 10 0	
	664 1 6	
Less 6% transferred to current revenue	39 16 9	
		624 4 9
Advance payments for *Monthly Notices*, Vol. 94		43 17 9
Credits for overpayments on publications, 1931 and 1932 ...		1 8 11
General Fund—		
As at 1932 December 31	16,689 3 11	
Add Potter Bequest...	318 16 2	
	17,008 0 1	
Add Excess of Income, over Expenditure, 1933... ...	335 18 8	
		17,343 18 9
		£22,855 12 4

Examined and found correct.

(Signed) C. O. BARTRUM
D. H. SADLER

1934 *January* 18

1933 *December* 31

ASSETS

	£ s. d.	£ s. d.
Sundry Debtors for Subscriptions in Arrears—		
20 for 1932	42 0 0	
78 for 1933	163 16 0	
		205 16 0
Sundry Debtors, 1932		0 11 10
Sundry Debtors, 1933 :—		
Due for Publications and Reprints	40 4 3	
Due for Photographs	0 1 0	
Due for Postages	0 1 9	
		40 7 0
Investments of General Fund—		
As at 1932 December 31 (valued as in 1932 Balance Sheet) 17,192 8 6		
Purchase (1933) of £300 War Stock 3½% (Potter Bequest) (valued at cost)	301 1 0	
		17,493 9 6
Investments of Special Fund, valued at cost		1460 0 0
Investments of Trust Funds, valued as in 1932 Balance Sheet		2964 0 0
Income Tax 1933 April–December, deducted at source and not yet refunded—		
General Fund	84 2 10	
Trust Funds	17 13 3	
		101 16 1
Sundry Balances—		
In hand of Assistant Secretary on Petty Cash Account ...	9 10 10	
At Bankers', on Current Account	464 17 0	
At Bankers', on "C" Account (Trust Funds) (including balance of Potter Bequest, £17, 15*s.* 2*d.*)	115 4 1	
		589 11 11
		£22,855 12 4

Astronomical and other Manuscripts, Books, Prints, Photographs and Instruments.
Furniture, etc.
Stock of Publications and Photographs for sale.
Two Gold Medals.
Four Bronze (Jackson-Gwilt) Medals.
} Not valued.

INVESTMENTS

As at 1933 December 31

General Fund

£1250 Metropolitan 3-per-cent. Stock, 1941.
£2000 Swansea Corporation 3½-per-cent. Irredeemable Stock.
£2287, 6*s.* 9*d.* East Indian Railway 3-per-cent. New Debenture Stock.*
£5125 London, Midland, and Scottish Railway 4-per-cent. Debenture Stock.*
£750 London, Midland, and Scottish Railway 4-per-cent. Preference Stock.*
£2400 Gas Light and Coke Co. 3-per-cent. Debenture Stock.*
£2000 Commercial Gas Co. 3-per-cent. Consolidated Debenture Stock.*
£496 Consolidated 4-per-cent. Loan, 1967.
£500 Agricultural Mortgage Corporation, Ltd., 4½-per-cent. Debenture Stock, 1961–91.*
£1000 Hull Corporation 4½-per-cent. Redeemable Stock, 1952–72.
£1000 Central Electricity Board 4½-per-cent. Stock, 1957–82.*
£2000 New Zealand 3½-per-cent. Loan, 1940.
£700 Birmingham Corporation 3-per-cent. Inscribed Stock, 1947.
£800 War Loan 3½-per-cent. Inscribed Stock.
£500 New South Wales 4-per-cent. Stock, 1942–62.*

Grove-Hills Special Fund

£419, 17*s.* 11*d.* Conversion Loan 4½-per-cent., 1940–44.
£695, 16*s.* 0*d.* Conversion Loan 3½-per-cent., 1961.
£535 Agricultural Mortgage Corporation, Ltd., 4½-per-cent. Debenture Stock, 1961–91.*

Five Trust Funds

£1212, 13*s.* 3*d.* East Indian Railway 3-per-cent. New Debenture Stock.*
£542, 18*s.* 2*d.* India 3½-per-cent. Stock.
£1004 Consolidated 4-per-cent. Loan, 1967.
£965 Agricultural Mortgage Corporation, Ltd., 4½-per-cent. Debenture Stock, 1961–91.*

* Taxed at source.

REPORT OF THE AUDITORS FOR THE YEAR 1933

We have examined the Treasurer's accounts of receipts and expenditure and the Revenue Account and Balance Sheet for the year 1933, and have certified them to be correct. The investment holdings have been certified either by the Bank of England or by the Westminster Bank, and are in accordance with the printed list. These investments are taken to account in the Balance Sheet at the market values on 1922 December 29, or on the date of purchase where later; these are substantially below the present market values.

The Revenue Account shows an excess of income over expenditure of £336. This satisfactory result in comparison with past years is due both to an increase in revenue and to a decrease in expenditure. The Royal Society have made a subvention of £50, from the Government Publications Grant, towards the cost of printing the *Geophysical Supplements* in 1933, in view of the fact that these are of more general than astronomical interest. It is to be hoped that this grant can be made an annual one. The increase in revenue is also due to the fact that this is the first year in which dividends have been received on the Lindemann Bequest. A large saving has been brought about in the printing costs by the more favourable contract with the printers; this will save the Society about £139 for a volume of 800 pages. The restriction of the size of Volume 93—100 pages less than Volume 92—and the cessation of the issue of free reprints to authors have also contributed to the reduction of expenditure.

The sum held to reserve in respect of the liability to Fellows who have compounded is now £624, an increase of £139 during the year.

A bequest of £318, 16*s*. 2*d*. has been received from the estate of the late Archdeacon Potter, and has been invested in 3½ per cent. War Stock, as shown in the Cash Account.

A list has been laid on the table containing the names of those Fellows who are in arrear for sums due on 1933 January 1, with the amount due against each Fellow's name.

The books, instruments and other effects on the premises appear to be in satisfactory order. Of the two books reported as missing from the library in the Auditors' Report for 1932, one, namely *Lick Observatory Bulletin*, vol. viii, has since been returned.

During the year there have been two notable additions of rare books to the library, purchased mainly out of the Harry Watson Memorial Fund. These books are:

Simon Marius, *Mundus Jovialis*, 1614.

Regiomontanus, *De Cometæ Magnitudine*, 1531.

The Society is to be congratulated on the discovery that the second copy

in the library of Kepler's *Tabulæ Rudolphinæ* contains the rare world map, missing from the first and from most copies.

The cabinet for photographic prints, purchased out of current revenue, will greatly assist in the handling of the Society's stock of photographs for sale.

We have received from the Assistant Secretary all the information and explanations we have required in the elucidation and certification of the accounts.

(Signed) C. O. Bartrum
D. H. Sadler

1934 *January* 24

GIFTS TO THE GENERAL FUNDS AND PROPERTY OF THE SOCIETY

The John Lee Gift: In 1836 John Lee, Esq., LL.D., gave the Advowson of the living of Hartwell; in 1844 he gave the Advowson of the living of Stone, Bucks. In 1879 these Advowsons were repurchased by his heir, Edward Lee, Esq., for £700.

The Lawson Bequest (1856): Henry Lawson, Esq., bequeathed to the Society the sum of £200, free of legacy duty.

The Carrington Bequest (1876): R. C. Carrington, Esq., F.R.S., bequeathed to the Society £2000 Consols.

The Lambert Bequest (1877): C. J. Lambert, Esq., presented to the Society the sum of £500, free of legacy duty, being part of a sum of money bequeathed by his father, Charles Lambert, Esq., for scientific purposes.

The McClean Bequest (1905): Frank McClean, Esq., LL.D., F.R.S., bequeathed to the Society the sum of £2000, free of legacy duty.

The Farrar Bequest (1906): The Rev. A. S. Farrar, D.D., bequeathed to the Society the sum of £100, free of legacy duty.

The Parsons Gift (1922): The Hon. Sir Charles Parsons, K.C.B., F.R.S., gave to the Society £2500 War Stock 1929–47, in memory of his father, the 3rd Earl of Rosse, who made the 6-foot reflector, and who died 1867 October 31.

The Grove-Hills Bequest (1922): Colonel E. H. Grove-Hills, C.M.G., F.R.S., bequeathed to the Society, free of legacy duty, his collection of early astronomical and mathematical books up to the year 1700, together with a sum of £250 to cover the expenses incurred by the Society in connection with the books.

The Lindemann Bequest (1931) : A. F. Lindemann, Esq., bequeathed to the Society the sum of £1000, free of legacy duty.

The Archdeacon Potter Bequest (1933) : Archdeacon Beresford Potter bequeathed to the Society a 3/88th share of his residuary estate, amounting to £318, 16*s.* 2*d.*

THE GROVE-HILLS SPECIAL FUND

In 1923 the Treasurer, Col. Grove-Hills, collected by his private efforts, with the approval of the Council, a Special Fund to meet the immediate financial difficulties of the Society. The total amount received from all sources (including dividends on the investments representing the fund) has been £1913, 1*s.* 11*d.*, of which £1480, 2*s.* 10*d.* has been invested and is now represented by £535 Agricultural Mortgage 4½ per cent., £419, 17*s.* 11*d.* Conversion Loan 4½ per cent. 1940–44, and £695, 16*s.* Conversion Loan 3½ per cent. 1961.

THE ARCHDEACON POTTER BEQUEST

The late Archdeacon Beresford Potter, who died 1931 May 10, bequeathed to the Society a 3/88th share of his residuary estate. This legacy was received in 1933, and amounted to £318, 16*s.* 2*d.* The sum of £301, 1*s.* has been invested in £300 3½ per cent. War Stock. The Council resolved to allocate the dividends from this investment for the purposes of the library.

TRUST FUNDS

The Lee and Janson Fund : In 1834 John Lee, Esq., LL.D., gave £100, and in 1876 T. C. Janson, Esq., bequeathed £200, the interest to be given to the widow or orphan of a deceased Fellow. These amounts now stand in £334, 10*s.* 9*d.* East Indian Railway 3 per cent. Debenture Stock.

	£	*s.*	*d.*
1933 Jan. 1. Balance of Fund	16	10	2
1933. Dividends, East Indian Railway ...	7	10	8
Income Tax, 1932 April–1933 April, refunded ...	2	10	0
	£26	10	10

	£	*s.*	*d.*
1933 Dec. 31. Balance of Fund	26	10	10
	£26	10	10

The Turnor Fund and the Horrocks Memorial Fund : In 1853 the Rev. Charles Turnor, M.A., bequeathed a sum of £500, which now stands in £464, 18*s*. East Indian Railway 3-per-cent. Debenture Stock. In 1876 the Society received a sum of £38, 15*s*., the unexpended balance of a fund collected for the purpose of erecting a memorial in Westminster Abbey to Jeremiah Horrocks : to this the Society added the sum of £55, 15*s*., and the whole now stands in £103, 6*s*. East Indian Railway 3-per-cent. Debenture Stock. The interest on these funds is to be used in the purchase of books for the library.

	£	*s*.	*d*.		£	*s*.	*d*.
1933 Jan. 1. Balance of Fund	4	10	3	1933. Purchase of Books ...	16	9	11
1933. Dividends, East Indian Railway ...	12	15	8	1933 Dec. 31. Balance of Fund	5	1	4
Income Tax, 1932 April–1933 April, refunded ...	4	5	4				
	£21	11	3		£21	11	3

The Harry Watson Memorial Fund : In 1920 Mrs. Watson presented to the Society the sum of £300 as a memorial to her late husband, Lieut.-Col. Harry James Watson, F.R.A.S., the interest on this sum to be used for the purchase of books for the library, such books to be indicated by a special book-plate. This gift now stands invested in £542, 18*s*. 2*d*. India 3½-per-cent. stock. In 1923 Mrs. Watson bequeathed a further sum of £958, 17*s*. to the Society, which now stands invested in £965 Agricultural Mortgage 4½-per-cent. Stock. The Council resolved that these two sums should together constitute a Trust Fund, to be designated *The Harry Watson Memorial Fund*, to be used for the purchase and binding of books.

	£	*s*.	*d*.		£	*s*.	*d*.
1933 Jan. 1. Balance of Fund	51	12	2	1933. Purchase of Books ...	57	11	8
1933. Dividends, India 3½ per cent.	19	0	0	Binding	43	4	6
Dividends, Agricultural Mortgage 4½ per cent.	32	11	6	1933 Dec. 31. Balance of Fund	7	16	0
Income Tax, 1932 Dec., refunded	5	8	6				
	£108	12	2		£108	12	2

The Hannah Jackson (née Gwilt) Fund : In 1861 Mrs. Hannah Jackson (*née* Gwilt) gave £300 Consols, which now stands in £309, 18*s*. 6*d*. East Indian Railway 3-per-cent. Debenture Stock ; the interest to be given in medals or other awards in accordance with the terms of the Trust.

	£	s.	d.		£	s.	d.
1933 Jan. 1. Balance of Fund	28	13	2	1933 Dec. 31. Balance of Fund	37	19	2
1933. Dividends, East Indian Railway ...	6	19	8				
Income Tax, 1931 April–1932 April, refunded ...	2	6	4				
	£37	19	2		£37	19	2

The George Darwin Lectureship Fund : In 1926 June the then President, Dr. J. H. Jeans, presented to the Society the sum of £1000 for the endowment of an annual lectureship, to be called *The George Darwin Lectureship*, the lecture to be on some subject of interest to astronomers, preference being given, in electing a lecturer, to one normally resident outside the British Isles.

This sum now stands in £1004 Consolidated 4-per-cent. Loan. The income is annually applied to the purposes of the Trust in accordance with the terms of the Deed of Gift.

	£	s.	d.		£	s.	d.
1933 Jan. 1. Balance of Fund	15	1	3	1933 May. Lecture Fee ...	50	0	0
Dividends, Consolidated 4 per cent. Loan	35	2	10	1933 Dec. 31. Balance of Fund	20	1	7
Donation from General Fund	9	16	10				
Income Tax, 1932 April–1933 April, refunded ...	10	0	8				
	£70	1	7		£70	1	7

CELESTIAL PHOTOGRAPHS

The following have been added to the list of Celestial Photographs reproduced by the Society for sale to Fellows :—

(*N.B.*—The reference numbers given are those in the new catalogue)

R.A.S. Ref. No.

R 1. Spectrum of Thallium (*under various conditions*). Dingle, S. Kensington.

R 2. Spectrum of Silicon Tetrafluoride (*with varying degrees of ionisation*). Dingle, S. Kensington.

S 6. Crossley Reflector, Lick Observatory. Ap. 36 inches, *f.l.* 17 feet 6 inches.

I 18. N.G.C. 2261. Hubble's Variable Nebula. Lowell Observatory. 1916 Mar. 2–1926 Jan. 14. 42-inch Reflector.

M 52. Spectrum of Venus and Sunlight. Lowell Observatory. 1921. 24-inch Refractor, 3-prism spectrograph.

N 16. Spectrum of μ Cassiopeiæ. Dominion Astrophysical Observatory, Victoria, B.C. 72-inch Reflector, 1-prism spectrograph.

R.A.S.
Ref. No.

J 89. N.G.C. 7331 (Pegasus) and Field of Nebulæ. Mount Wilson. 1916 Aug. 28. 60-inch Reflector. Exp. 6¼ h.

P 4. Spectra of Nova Pictoris. Royal Observatory, Cape. 1925 May 25–July 25. 24-inch Refractor, 4-prism spectroscope.

P 5. Spectra of Nova Pictoris. Royal Observatory, Cape. 1925 July 18–Sept. 22. 24-inch Refractor, 4-prism spectroscope.

P 6. Spectra, Nova Pictoris, Nova Aquilæ, η Carinæ. Royal Observatory, Cape. 24-inch Refractor, 4-prism spectroscope.

P 7. Spectra of Nova Pictoris. Royal Observatory, Cape. 1925 Dec. 8–1926 Mar. 2. 24-inch Refractor, 4-prism spectroscope.

P 8. Spectra of Nova Pictoris. Objective prism. Union Observatory, Johannesburg, 1926 Mar. 20–Oct. 4. Royal Observatory, Cape, 1928.

S 10. Airy's Transit Circle. Royal Observatory, Greenwich. Ap. 8 inches, *f.l.* 12 feet.

N 17. Spectra of Field of Stars in Cygnus. Hamburg Observatory. Schmidt Coma-free Reflector, Ap. 36 cm., *f.l.* 62·5 cm., with 8° objective prism.

M 53. Spectra of Jupiter, Saturn and Venus. Slipher, Lowell Observatory. 3-prism spectrograph. (*Showing rotation.*)

ERRATA IN CATALOGUE OF REPRODUCTIONS OF CELESTIAL PHOTOGRAPHS

Moon. D 11.—*For* 1901 Aug. 3, age $18\frac{1}{2}^{d}$, *read* 1901 Sept. 3, age $19\frac{1}{2}^{d}$.
D 14.—*For* 1901 Nov. 21, age $10\frac{1}{2}^{d}$, *read* 1901 Nov. 20, age $9^{d}\ 17^{h}$.

PUBLICATIONS OF THE SOCIETY

During the past year the Society has published *Monthly Notices*, vol. **93** ; *Geophysical Supplements*, vol. **3**, Nos. 3, 4 ; *Memoirs*, vol. **65**, pt. 2 ; and *Catalogue of Reproductions of Celestial Photographs.*

OBITUARY

The Council regret that they have to record the loss by death of the following Fellows and Associate during the past year:—

Fellows:—Alfred Dillon Bell
Claude de la Cherois Crommelin
John Edwards Griffith
Ernest William Hobson
Leon Hufnagel
Robert Thorburn Ayton Innes
Frederick William Longbottom
Edmund Sixtus Phillips
* Charles Frederick Plant
John Merrill Poor
Thomas Cunningham Porter
Govind Padmanabha Rao
Edward Roberts
Robert Charles Sclater
William Francis Herschel Waterfield
Associate:—William Lewis Elkin

ALFRED DILLON BELL was born at the Hutt, Wellington, New Zealand, in 1851. He was the son of Sir Francis Dillon Bell, a distinguished New Zealand pioneer and statesman. He was educated at Auckland Grammar School and Otago Boys' High School, where he won the Chamber of Commerce medal for arithmetic. Shortly after leaving school he went to live at the Shag Valley homestead, where he resided almost continuously till his death.

Mr. Bell devoted a great deal of attention to chemistry and physics. He constructed the first telephone line in New Zealand. He was an original member of the New Zealand Astronomical Society and had a 5-inch Cooke refractor mounted equatorially in a small observatory built on his house.

He married the second daughter of Mr. H. W. Robinson, District Judge. He died at Shag Valley Station on 1933 April 15.

He was elected a Fellow of the Society on 1929 January 11.

L. J. C.

CLAUDE DE LA CHEROIS CROMMELIN, eldest son of Dr. A. C. D. Crommelin, was born 1899 September 12 and died 1933 July 4.

He was educated at Stratheden House, Blackheath, and Dulwich College. After winning a scholarship he passed to Trinity Hall, Cambridge, where he took a Second Class in the Mathematical Tripos in 1921.

* Died in 1932. Death not notified till 1933.

During the War he naturally thought of a military career, and whilst at Dulwich College passed the Sandhurst examination but was rejected on medical grounds. He then trained for the Artillery and passed for a Commission, but the Armistice prevented active service.

After graduating he engaged in tutorial work, but ultimately obtained an appointment under the Western Electric Cable Co. and later with Siemens at Charlton.

His principal study was the Theory of Probability as applied to problems of telephonic communication, and he published several papers on the subject in various electrical magazines, one of which was translated and published in a German electrical magazine. At the time of his death he was writing a book on the subject, which, though not complete, it is hoped may yet be published.

Of a gentle and retiring disposition, he was passionately fond of music and a regular attendant at Covent Garden during the Opera season. Country dancing, cycling and mountaineering were his recreations, and it was whilst engaged on the last that the tragic accident occurred when, with his sister Philomena, also an enthusiastic rock climber, he met his death on Pillar Rock, Ennerdale.

His interest in astronomy began at Cambridge, when he read astronomy under Eddington. His subsequent energies were mostly absorbed in the subject of his profession, but he found time to contribute an article on the "History of the Earth-Moon System according to the Tidal Theory," published in the *Splendour of the Heavens*.

He was elected a Fellow of the Society 1923 January 12.

C. R. D.

JOHN EDWARDS GRIFFITH died, at the age of ninety, at his home, Bryndinas, Upper Bangor, on 1933 July 4. He was the son of Mr. Griffith Griffith of Taldrwst, Llangristiolus. He followed a business career and was a man of many interests. He was the author of *Flora of Anglesea and Cærnarvonshire* and *The Cromlechs of Anglesea and Cærnarvonshire*.

Griffith was married twice, firstly to Miss Parry, daughter of Mr. Rowland Parry of Pennsylvania and Fronheulog, Bangor. After her death Griffith married Miss Williams-Ellis, daughter of Mr. John Williams-Ellis of Plas Lodwig. At the time of his death Griffith was the oldest magistrate in the Bangor division.

He was elected a Fellow of the Society on 1878 February 8.

ERNEST WILLIAM HOBSON. An obituary notice will appear in a subsequent number of the *Monthly Notices*.

LEON HUFNAGEL commenced his university studies in Warsaw, and moved later to Vienna to do post-graduate work on comets under Oppenheim. From 1921 to 1926 he was an Assistant at the University of Warsaw. At this period he devoted all his spare time to the study of astrophysics and interested himself in Eddington's work on stellar motions. At the

same time he continued his work on the orbits of comets and of minor planets. In 1926 Hufnagel went to Lund for two years, where he worked on the statistics of stellar velocities. After this he went to the United States for a further two years as a Rockefeller travelling Fellow. A result of this visit was a paper on the galactic rotation and the temperatures of giants and dwarfs. At the time of his death Hufnagel was engaged in writing, together with Professor v. d. Pahlen, a treatise on stellar dynamics. He died, aged thirty-nine years, on 1933 February 19, as a result of inflammation of the lungs following upon a chill.

He was elected a Fellow of the Society on 1929 January 11.

R. v. d. R. W.

ROBERT THORBURN AYTON INNES was born in Edinburgh on 1861 November 10, and died at Surbiton near London from heart failure on 1933 March 13. He was a physically strong man, always in good health, who had never suffered from any serious illness during his life, and his death came quite unexpectedly to his friends. He leaves a widow and three sons, all married, who live in Johannesburg.

Innes's life has been a full and happy one. He was a man of little needs, quite content with a simple life in the circle of his family and friends. He married young, and his marriage was a model of simple domestic happiness. The delight with which he and Mrs. Innes watched the development of their boys when they were growing up, and later their success in life, the atmosphere of quiet love and happiness that they created around them, made their house the ideal home, to which friends often came, and to which attraction was added by Innes's often original and stimulating conversation on various topics, enlivened by humorous touches, particularly his own, and by a little good-natured friendly teasing now and then. In the later days, in Johannesburg, his house was always open to the younger astronomers and their wives, who used to call Mrs. Innes "mother."

But, although the social and human side of life had his warm interest, Innes was first of all an astronomer. He might be taken as the typical example of the "amateur," that variety of the astronomer species that is most frequent, and reaches its highest development, in Anglo-Saxon countries, and he remained a typical amateur even when he was a professional astronomer and head of a government observatory. He was elected a Fellow of the Society before he was eighteen years of age (1879 January 10). At first he concentrated his efforts on theoretical work, having no means to purchase a telescope. And the theory of the motions of the heavenly bodies retained his preference throughout his life. Even when he had his own observatory, he used to say that he was an observer only by necessity; but a mathematical astronomer by choice. A man's judgment of his own accomplishments often differs from that of his contemporaries, or of posterity, and Innes's name will certainly live in the annals of astronomy primarily as that of a first-rate observer. Still the work he did in the domain of celestial mechanics is important and very remarkable, especially if it is remembered that he never had any mathematical schooling, and

during practically the whole of his life had few opportunities for interchange of ideas with other authorities on the subject. Perhaps the best known is his work on the rotation of the earth, in the course of which he gave a new reduction of all observed transits of Mercury. First of all he was a computer. For him mathematics existed only as a means to an end. The point of view of the pure mathematician had little attraction for him. "Is Poincaréism astronomy?" he asked, as a reply to the present writer's confession of the fascination that Poincaré's theory of periodic orbits had for him. But he easily and completely mastered the most difficult branches of mathematics if he saw in them a possibility of improving the certainty and shortness of computation. His use of Weierstrass's elliptic functions, his work on Hansen's theory, on Newcomb's operators and on the theory of Jupiter and Saturn may be quoted as examples of this character of his work. The speed and accuracy with which he performed the most intricate numerical computations was most wonderful to behold.

He had, of course, "les défauts de ses qualités." His trend of mind made him liable to overestimate the importance of the numerical result as against the mathematical foundations. His advocacy of the computation of the places of the planets by numerical integration (by Cowell's method, or similar devices) instead of from developments in series is perhaps the most typical example, but his proposal to use galactic co-ordinates instead of right ascension and declination, to evade the many difficulties and problems of precession by ignoring it, and even such purely formal things as the use of *S*, *C*, *T* instead of *sin*, *cos*, *tan*, belong to the same category. He had strong opinions, and liked to express them strongly, especially if they were somewhat paradoxical and contrary to the commonly accepted views. Even in such external things as spelling, or dress-reform, he liked to show the same freedom from convention. Perhaps it was this same practical tendency of his mind that made him an expert chess and bridge player. And this same practical outlook and freedom from tradition made him see things that escaped the attention of others. Thus, to mention only one example, he seems to have been the first to realise that the changes in the rotation of the Earth (by which the fluctuations in the motion of the Moon and other heavenly bodies are explained) take place *by jumps*, and not continuously according to some development in a Fourier series.

Early in life Innes went to Australia to earn his living in business, and settled as a wine merchant in Sydney, N.S.W. There he began his career as an observing astronomer, and he remained faithful to the southern hemisphere ever after. His first instrument was an old six-inch refractor by Cooke, borrowed from Mr. W. F. Gale, and mounted on a rough equatorial stand without circles. With this telescope he discovered a number of new double stars (the first list of 26 new pairs was published in 1894 December), and thus was the first to reveal the untold wealth of discoveries that were still in store for the southern observers in this branch of astronomy. What is it that makes a man a double star observer? Innes could measure with entire certainty a double star which Gill—one of the most accomplished observers that ever lived—did not even see double. It is probably, in the

first place, as a double star observer that Innes's name will go down to posterity. What he has done in this branch not only by his discoveries, numbering about 1500, and his many measures, by his Reference Catalogue of Southern Double Stars (1899), by the Southern Double Star Catalogue, published in loose leaf form by himself and van den Bos, but also by his kindling enthusiasm and encouragement of younger astronomers, entitles him to be considered as the founder of double star astronomy in the southern hemisphere.

Once the fascination of astronomical observation got hold of him, it took possession of him to the exclusion of all other considerations. The ardent desire to have the disposal of good instruments made him write to Gill. He came to the Cape in 1896 (an observation of the double star I 27 dated 1896·4 was still made in Sydney, whilst 1896·5 there is an observation of I 109 at the Cape) and joined the staff of the observatory as a "clerical assistant" on 1897 January 1. The change meant a considerable pecuniary sacrifice, but enormous astronomical gain. His official duties were entirely administrative, "counting cakes of soap" as he used to say, but he acquitted himself of them most efficiently, and all his spare time was given to astronomy. Most of his observing was done with the old (1849) 7-inch refractor by Merz (mounting by Troughton & Simms, micrometer by Repsold). In addition to his double star work (continued later with the 18-inch visual telescope of the McClean equatorial) and many observations of occultations, of comets, etc., the whole of the Revision of the Cape Photographic Durchmusterung (which, amongst other results, led to the discovery of the big proper motion star Z.C.V^{h}. 243) was made with this instrument. His visual estimates of magnitudes proved to be as accurate and reliable as his double star measures. Besides the work for the revision of the C.P.D., and observations of variable stars generally, he made a great number of visual estimates of magnitudes of stars at the request of de Sitter, who discussed and published these observations in *Groningen Publications*, 12.

In 1903 a meteorological service was installed in the Transvaal, and, on the recommendation of Gill, Innes was made the Government Meteorologist. An observatory was founded in Johannesburg—or rather outside Johannesburg, in fact so far outside that, as the present writer remembers well, cab-drivers refused to go so far into the country after sunset. On the occasion of the visit of the British Association to South Africa in 1905 a representative gathering of astronomers (including Gill, Kapteyn, Backlund and many others) waited on His Excellency the Governor on the top of the kopje, and pointed out the excellence of the site for a big telescope. At that time from the highest point of the hill one could see two, or perhaps three, houses. When the British Association revisited Johannesburg in 1929, the big telescope was there, but surrounded on all sides by the expanding city. The telescope, a 26-inch visual refractor, designed especially with a view to double star observing, was ordered from Sir Howard Grubb in 1909, thanks largely to the influence of the Hon. Johannes F. B. Rissik (the man after whom Johannesburg is named), who was then Minister for the Interior. "Still it will be, I suppose, two years before it is all ready for use," Innes

wrote on 1909 August 23. Actually it was only ready for work on 1925 February 11, and Innes only used it for less than three years, as he retired from office at the end of 1927.

From 1903 to 1912, during which time Innes was head of the meteorological service, he nevertheless remained an astronomer. Meteorology was for him what his clerical duties had been at the Cape ; he organised and directed the service in his usual efficient way, but gave all his spare time to astronomy. During these years, and the years from 1912 to 1927 when the observatory was a purely astronomical one, together almost a quarter of a century, Innes's astronomical activity was unabated. Among the great wealth of observational results that emanated from Johannesburg we may perhaps make special mention of three large pieces of work : the determination of many proper motions by the blink-microscope, of which instrument he was one of the first to appreciate the possibilities, and which led, *inter alia*, to the discovery of Proxima Centauri ; the publication, which is still being continued, of the photographic charts, undertaken on the example of the Wolf-Palisa charts for the northern hemisphere ; and the great series of observations of phenomena of Jupiter's satellites, started in 1908 and intended to be sustained through one complete revolution of Jupiter, but actually continued much longer. The observations from 1908 to 1926 were reduced by Dr. Brouwer, and published in *Leiden Annals*, **16**, part 2. Besides these great undertakings, to which after the erection of the 26-inch the observation of double stars was added, miscellaneous observations were made of almost every possible kind : drawings and photographs of Halley's and other comets, of Mars and other planets, observations of occultations, discovery and observation of minor planets, etc., etc. Simultaneously with this very fertile observational activity Innes continued his theoretical work, on which he was able to concentrate all his powers after his retirement from office. A few months before his retirement he wrote : "I feel too active and don't exactly know what I shall do when I retire—of course I have some work on hand . . ." and then the letter goes on summing up enough work to keep an ordinary man busy for a dozen years or so. Much of this was accomplished in the following five years.

Still, as already pointed out in the beginning of this notice, it is as an observer that astronomy owes most to Innes, and more particularly as a *southern* observer. And that not only for his own observations but also, and perhaps even more so, for his kindling enthusiasm. It is always dangerous to say how events would have developed if such and such a thing had not happened, or had been different, but it seems certain that the very important position that South Africa occupies in the astronomical world to-day is due in great part to Innes, to his persistence in drawing attention to the splendid climate, and to his influence in persuading the authorites to welcome the foundation of southern stations by northern observatories. He was firmly convinced that the interests of astronomy urgently demanded more *observations* in the southern hemisphere. The theoretical work could be carried out in the North. In 1923, when he came to Leiden to receive the degree of doctor, *honoris causa*, that the University had conferred upon him,

almost the first thing he did was to propose to the director of Leiden Observatory the plan of co-operation between the two observatories, which has now been working for over ten years, and has proved so eminently fruitful in results. And when in 1927 Dr. van den Bos, who was then the Leiden observer at Johannesburg, was proposed for appointment as chief assistant of the Union Observatory, he wrote to Leiden: "The new man that you send out should be an 'observer,' and able to use our instruments. . . ." Innes was in many respects a pioneer of observational astronomy in the South, and he looked upon himself decidedly as a citizen of the southern hemisphere. It was a great satisfaction to him to see the Union of South Africa, that he loved and had adopted as his country, take a prominent place amongst the nations in his chosen science, which he loved still more.

W. DE S.

FREDERICK WILLIAM LONGBOTTOM was born at Scarborough. He followed a business career and was keenly interested in practical astronomical work which, in his case, was not a mere hobby, but an intense enthusiasm which lasted from his boyhood to his last days. The greater part of his life was spent in Chester, where his infectious enthusiasm led to quite a number of his acquaintances taking up work with the telescope. Longbottom had an extensive practical acquaintance with the sky, and even in the dusk he could set his 18-inch altazimuth on any interesting object. At a later date he took to photography, especially of comets and meteors. He was an original member of the British Astronomical Association and for twenty-one years he was Director of its Photographic Section. During this period he contributed many notes on Celestial Photography to the Association's *Journal*.

On his retirement from business he left Chester and retired to Boscombe, Hants, where he died on 1933 March 7 in his seventy-sixth year, just after he had begun work with a new telescope. His bright manner and merry quips will long be remembered by those who knew him.

He was elected a Fellow of the Society on 1905 June 9.

THE REV. FATHER EDMUND SIXTUS PHILLIPS died on 1933 August 12 at the age of sixty-three. He was educated at the Erdington Grammar School at Freshfield, and at Mill Hill. He was ordained priest by Cardinal Vaughan in 1895 and went to India where he joined the staff of St. Mary's College, Madras. His health, however, did not allow him to remain in India. His subsequent career included an appointment at Oscott College, Birmingham, where he remained for fourteen years. In 1918 he was appointed Priest-in-Charge of St. Austin's Church at Kenilworth, and remained there until 1929 when he returned to Oscott as Bursar. But his health was beginning to fail, and in the following year he became priest at Avon Dasset, near Leamington. Towards the end of 1932, having undergone an operation, he went to reside at Littleworth, Chipping Camden, Gloucestershire, where he died.

His natural vocation was that of a schoolmaster, and among all the varied

activities of school life there was none in which he was not interested. His natural bent was scientific, and in particular he took a keen interest in astronomy and seismology. He designed and built the observatory at Oscott. He was also a keen photographer.

He was elected a Fellow of the Society on 1910 January 14.

JOHN MERRILL POOR was born in West Newbury, Massachusetts, on 1871 January 28. He died at the Deaconess Hospital, Boston, on 1933 December 11, following an operation for cancer, and was buried at Hanover, New Hampshire, the town of his residence, on 1933 December 15.

John Poor attended public school in West Newbury until 1888, and worked as an apprentice during the next three years before entering a private preparatory school. In 1893 he entered Dartmouth College as a freshman, and received his Bachelor of Arts degree in 1897 June. During the year following his graduation from college he was Principal of Hanover High School, and in the fall of 1898 he began his teaching career at Dartmouth as Instructor in Mathematics and Astronomy.

Mr. Poor did graduate work at Princeton University from 1900 to 1902, as recipient of the Thaw Fellowship in Astronomy, and in 1902 he returned to Dartmouth as Instructor in Astronomy, thus beginning thirty-one years of continuous service in that department. During the summer of 1902 he was research assistant at Yerkes Observatory, and after further graduate work at Princeton during the year 1903 he was awarded his Ph.D. degree there in 1904. Professor Poor's graduate studies were continued later, during the fall term of 1911–12, at Lund University, Sweden, where he worked with Charlier.

In 1906, after four years as Instructor at Dartmouth, Mr. Poor was made Assistant Professor of Astronomy, and nine years later, in 1915, he was promoted to Associate Professor. In 1917 he became full Professor of Astronomy, a position which he held up to the time of his death. His courses at Dartmouth dealt with Astronomy, Meteorology, Navigation and Astrophysics.

Professor Poor was a member of Phi Beta Kappa, Theta Delta Chi fraternity and Gamma Alpha. He was a member of the American Astronomical Society, the American Meteorological Society and the American Mathematical Society. Professor Poor continued the series of meteorological records of the Shattuck Observatory, supplying data to the United States Weather Bureau, and carrying on what, because of its duration in years, is considered one of the most valuable series of weather observations in America. Professor Poor's weather observations have been published in various meteorological publications of the United States Government and in college journals throughout this country. Professor Poor also contributed articles to *The Astronomical Journal* on "The Orbit of Comet 1900–II" (1907) and "Orbit Planes of Binary Stars" (1914).

Professor Poor married Helen Noyes, of West Newbury, Massachusetts, in 1905, and is survived by his wife and two daughters, Dorothy Noyes and Elizabeth Merrill Poor.

He was an ardent musician and was president of the Handel Society Symphony Orchestra, of Hanover, from the time of its foundation up to the time of his death. One of the best-loved men at Dartmouth College, he always appeared about campus with his chalk-spotted blue serge suit, black bow tie, and corncob pipe. He was a philanthropist in his modest way, and was known to thousands of Dartmouth students for his dry wit, the anecdotes which clustered about his name, and for his hospitality on Observatory Hill, where he kept an almost nightly vigil among his telescopes and astronomical instruments.

He was elected a Fellow of the Society on 1924 April 11.

THOMAS CUNNINGHAM PORTER was born at Bristol on 1860 February 16. From Bristol Grammar School he gained a scholarship to Exeter College, Oxford, where he took honours in mathematics and natural science. After a short experience on the staff of Carlisle Grammar School he took up an appointment at Eton which he held till his retirement in 1930. In 1900 he was an originator and co-founder of the Public Schools Science Masters' Association, which was later expanded to include all secondary schools and became the Science Masters' Association.

He was a man of many interests and great gifts. He had the experimental technique which enabled him to design and improve apparatus as well as to manipulate it skilfully, and in his numerous researches he met with some success, though the results of much of his major work disappointed him. In 1905 he proceeded with Mr. W. P. Colfox on a private expedition to Algeria to view the total eclipse of the Sun, and a full report appeared in the *Proceedings of the Royal Society* in 1907. He had some skill as an artist and was a very fine photographer, but it is as a lecturer in science that he will be best remembered, for he had a wonderful power of arousing interest and inspiring enthusiasm. He earned the affection of many generations of Etonians, and even after he had retired and his voice was weak he continued to do a little teaching and to keep touch with the school. He liked walking and bicycling and his love of mountains often drew him to Norway in the holidays. Although he had to relinquish some of his activities in his last few years there seemed to be no other change, for he never grew old.

In 1893 he married Helen Henrietta Allenby, a sister of Field-Marshal Lord Allenby. There were no children. He died on 1933 March 31.

He was a Doctor of Science of Oxford University and was elected a Fellow of the Society on 1885 January 8.

C. M.

GOVIND PADMANABHA RAO was born on 1906 October 7. After graduating in the University of Madras, he joined the Survey of India in 1926 as a Sub-Assistant Superintendent in the Dehra Dun Computing Office. He was keenly interested in the mathematical aspect of survey work and was the author of some papers published in the *Empire Survey Review* in 1932 and 1933. The *Monthly Notices* for 1932 June contained a paper by

Rao entitled "A Preliminary Discussion of Latitude Variation at Dehra Dun." He died on 1933 September 18.

He was elected a Fellow of the Society on 1932 April 8.

EDWARD ROBERTS was born in Deptford Broadway in 1845 and was educated at the Greenwich Proprietary School under the Rev. Thomas Goodwin, LL.D., where he gained many prizes, mainly in chemistry and mathematics; on leaving school in 1860 he was introduced by the Rev. R. Main, then first assistant, and given a place on the staff at the Royal Observatory, Greenwich.

While there, in addition to the routine work of computing and observing, he was engaged on extraneous work by the Astronomer Royal and Mr. Main, and was appointed to the Nautical Almanac Office in 1864, where his varied experience was of great service. The writer, five years junior to Roberts, remembers being impressed with the extraordinary neatness of his work and the beauty of his figures, both of which features he combined with extraordinary speed and accuracy.

He also had an odd ability to drop straight on an error that had defied its maker in perhaps half an hour's search, and it is certain that in this particular he never had his equal in the office.

Roberts's association with Lord Kelvin (then Sir William Thomson), who used to boast of his inability to add up a laundry bill, was a most fortunate incident for the younger man, and gave him a chance to share in the design and production of the original tide machine so courageously ordered by the India Office, and its later counterparts which carry on mechanically the work of Roberts's industrious pen.

He died on 1933 August 4.

He was elected a Fellow of the Society on 1872 February 9.

P. L. H. D.

ROBERT CHARLES SCLATER, who died on 1933 March 27, was the science master at Charterhouse. He took up that position in 1896, was a house-master from 1910 to 1924, and retired in 1932. An obituary notice in the school magazine speaks of his skill as a teacher due to the clearness of his explanations and his capacity for extracting excellent experimental results from insufficient or unsuitable apparatus. It seems that astronomy was not a subject for class-teaching, but a school telescope was available, and with this he showed the heavenly bodies to the boys and to his colleagues.

He was born at Blackheath on 1872 June 13, the youngest son of Mr. Robert Slater, banker (his younger sons reverted to the earlier Scottish spelling, Sclater, that had been used by their great-grandfather), and, after schooldays at Clifton College, was elected to a scholarship at Peterhouse, Cambridge. He was in the 1st Class in the Natural Sciences Tripos in 1894, and after a short service as Instructor at the Royal Naval Engineering College at Keyham, took up the position at Charterhouse already mentioned.

Sclater had a $5\frac{1}{2}$-inch refracting telescope that he used principally for observing sunspots and prominences and took for use in several eclipse

expeditions. He went with Mr. Evershed's party to Spain in 1905, when unfortunately clouds prevailed; to Ovar, Portugal, in 1912 for the annular eclipse, and in 1914 he set out for Russia, but got only as far as Sweden where he took some photographs of the total phase. He joined the British Astronomical Association in 1905 November and acted for some time as secretary.

Sclater was a skilful musician, a performer on the violin and other instruments, and took part in this way in the school concerts and at festivals. His chief hobby was yacht-sailing, his skill in which art has been inherited by his daughter. He married in 1908 Katharine, younger daughter of Sir Augustus Oakes, C.B., whom he leaves a widow with one son, an officer in the York and Lancaster regiment, and one daughter.

He was elected a Fellow of the Society on 1909 March 12.

WILLIAM FRANCIS HERSCHEL WATERFIELD was born on 1886 June 1. His mother was Rose, seventh daughter of Sir J. F. W. Herschel, one of the founders of our Society. He was educated at Westminster School and Christ Church, Oxford. His active interest in astronomy dated from about the time when he was an undergraduate. He then had the use of a 5-inch refractor belonging to his father; but when it became evident that his interest in the science was a serious one, his uncle, Col. John Herschel, presented to him a much larger instrument, a $12\frac{1}{4}$-inch equatorial reflector by Calver. This was in 1910, but, owing to residence abroad and war service (he held a commission in the R.G.A.), he was hardly able to use his telescope at all until 1919; but he generously lent it in the meantime to another enthusiastic amateur, who made good use of it.

In 1919, after his demobilisation, he returned to his farm in British Columbia, and settled down to work on variable stars with the reflector. During the next seven years he contributed to the Variable Star Section of the British Astronomical Association a great number of careful observations, which were specially valuable in the case of the deep minima beyond the range of smaller instruments.

The sudden death of his wife, who was accidentally drowned in 1926, changed the course of his life. He sold his farm and telescope, and joined the staff of the Harvard College Observatory under Dr. Shapley. Here he continued to work on variable stars, but now chiefly on the theoretical side. His marked ability led to his appointment, in 1928, as assistant to Dr. Paraskévopoulos at the Harvard Southern Station near Bloemfontein, South Africa. On 1933 May 16 he was on his way to the Observatory from the town when his motor cycle came into collision with a native cart, and he sustained injuries from which he died almost immediately. He leaves three children, all under age.

He was elected a Fellow of the Society on 1926 February 12.

WILLIAM LEWIS ELKIN.—By the death, on 1933 May 29, of William Lewis Elkin the Society lost its senior Associate. Elkin's election antedated by seven years that of any Associate surviving at the time of his death.

He was an Associate of the Society for more than forty years, a record which can seldom have been equalled in the history of the Society.

Elkin was born in New Orleans on 1855 April 29, the son of Lewis and Jane Fitch Elkin. He had a number of brothers and sisters, none of whom survived childhood. His father died when he was about twelve years of age. Shortly afterwards his mother took him to Europe. He attended private schools in Lausanne, Switzerland, until he entered the Royal Polytechnic School at Stuttgart, where he graduated in 1876. He then went to Strassburg and studied for four years under Winnecke, who had the reputation of being the greatest teacher of practical astronomy of his day. In 1879 David Gill, on his appointment as H.M. Astronomer at the Cape, visited a number of Continental observatories before leaving for South Africa. Strassburg was one of the observatories included in the itinerary, and Gill always regarded this visit as a specially memorable one. There he met not only Winnecke but also Winnecke's senior students in astronomy—Küstner, Hartwig, Hermann Struve, Ambronn and Elkin. He learned that Elkin had selected as the subject of the inaugural dissertation for his doctor's degree, "The Parallax, Proper Motion and Masses of α_1 and α_2 Centauri." Gill informed Elkin that he intended to use the 4-inch heliometer, which he had just purchased from Lord Crawford, to make observations at the Cape for the determination of stellar parallax. Elkin expressed great interest in the programme and a keen desire to take part in such work. Gill therefore invited him to come out as his guest, on the completion of his University curriculum, and to share in the observations. Elkin took his Ph.D. in 1880, and shortly afterwards left for the Cape, where he arrived on 1881 January 31. The programme of observations which Gill had planned was designed to extend over a period of eighteen months and to make as important a contribution to the existing knowledge of the parallax of southern stars as was possible in that time. The parallaxes of three stars were to be independently determined by both Gill and Elkin, employing different comparison stars, in order to test the reliability of the results obtained; other stars were to be observed by one observer only. This programme was carried out in its entirety, and the results obtained for the nine stars provided the first reliable data as to the parallaxes of southern stars. Elkin lived as a guest and member of Gill's family circle until the completion of the programme, and the two men formed a strong attachment for each other which lasted until Gill's death in 1914. Gill stated that Elkin's work at the Cape "from first to last, was a labour of love." Gill was an incomparable observer with the heliometer, probably surpassing in skill and accuracy any other observer with this instrument before or since. He was fully cognisant of the various types of systematic error which might affect the observations, and took great care to plan the observations so that such errors should be either eliminated or controlled. The time which Elkin spent at the Cape was a valuable training in the use of the heliometer, the instrument with which nearly all of his own subsequent work was to be done.

In 1884 Elkin was appointed assistant in charge of the heliometer at

the Yale University Observatory. H. A. Newton, who had been appointed Director of the Observatory in 1882, resigned this post in 1884, but continued, as Secretary of the Board of Managers, to control the policy of the institution until his death in 1896. No appointment to the post of Director was made during that period. In 1896, on Newton's death, Elkin was appointed Director of the Observatory, and he held this post until ill-health caused his retirement in 1910.

The preliminary programme at the Cape had satisfied Gill and Elkin of the suitability of the heliometer as an instrument for the accurate determination of stellar parallax. The limited aperture of the 4-inch heliometer had unduly hampered, however, the choice of comparison stars, and Gill, in 1884, had asked the Admiralty for a 7-inch heliometer. The heliometer at the Yale Observatory was an instrument of 6 inches aperture which had recently been constructed by Repsold. The first programme of work on which it was employed by Elkin was the triangulation of the Pleiades, the positions of 69 stars being accurately determined and their motions investigated from such material as was available; some evidence of common motion was obtained. But Elkin was not long in undertaking stellar parallax observations, and between 1885 and 1894 an extensive series of observations were made for determining the parallaxes of 10 first-magnitude stars. The final values obtained by Elkin for the parallaxes of these stars are for the most part in satisfactory agreement with the values given by modern photographic methods, and though the probable errors are about double those of modern determinations, they were a great improvement upon what was possible by meridian observations.

In the meantime the failure of the Transit of Venus expeditions of 1874 and 1882 had turned Gill's thoughts again to the determination of the solar parallax by observations with the heliometer of suitable minor planets. Gill had already made a trial of such observations when he observed Juno at Mauritius in 1874, and his observations of Mars at Ascension in 1877 had convinced him of the value of the heliometer for this purpose. He decided that the oppositions of Iris in 1888 and of Victoria and Sappho in 1889 would provide favourable opportunities for the determination of the solar parallax. The employment of the diurnal method was considered, but as it would have been necessary to observe at a station near the equator in order to obtain the greatest advantage of the method, Gill decided to seek the co-operation of Elkin and the Yale heliometer for a programme of simultaneous observations. This co-operation was readily given by Elkin. The programme for the observations of Iris was planned in the expectation that the Cape and Yale heliometers would be the only co-operating instruments. Comparison stars were selected such that the line joining the stars should be nearly vertical for the observations both at the Cape, where they were to be made in the early morning at a western hour-angle of about three hours, and at Yale, where they were to be made in the evening at an eastern hour-angle of about three hours. The maximum parallax factor was thus in each case along the line of the measured distances. The programme was later somewhat modified by the co-operation of the heliometers

at Leipzig and the Radcliffe Observatory. The observations at Yale were shared by Elkin and Hall. For the oppositions of Victoria and Sappho a much wider scheme of co-operation was arranged by Gill, but in each case the majority of the observations in the northern hemisphere were made at Yale.

Gill undertook the discussion of the Victoria and Sappho observations, and Elkin undertook the discussion of the Iris observations. Elkin's discussion, containing an exhaustive investigation of the various possible errors of a systematic nature, was published in *Cape Annals*, vol. vi. The final outcome of the three programmes was a value of the solar parallax greatly exceeding in accuracy any previous determination. This value was closely confirmed by the result derived by Hinks from the extensive programme of observations of Eros at the opposition of 1901. A side-product of the observations was a much improved value of the lunar inequality of the Earth's motion, and thence, combined with the derived value of the solar parallax, of the mass of the Moon. It was the whole-hearted co-operation of Elkin in Gill's plans which made these results possible.

At about this time Elkin also undertook, at the request of E. C. Pickering, a triangulation with the heliometer of the stars in the neighbourhood of the Pole. Pickering required accurate positions to serve as the basis for a photographic survey of the polar region. Other observations which were made included the determinations of the diameters of the Sun, Venus, Mars and Saturn, and a series of observations of the satellites of Jupiter.

But after the completion of the minor planet observations, Elkin soon reverted to stellar parallax observations. In 1892 a reconnaissance survey of stars not fainter than magnitude 8·8 with proper motion exceeding 0″·4 per year and of unknown parallax was commenced. The intention at first was to secure a small number of observations at each of two successive epochs of maximum parallactic displacement so that, the proper motion being assumed known, parallaxes as large as 0″·20 would be detected with certainty and many as large as 0″·10 would also be detected. This plan was modified as the work proceeded, and the observations were extended through two more epochs in the reverse order. In this way a pretty fair approximation to the parallax was anticipated ; it was not intended that the results should be of the highest accuracy of which the instrument was capable. The observations of this programme extended over about thirteen years and were shared by Elkin, Chase and Smith. The programme did not lead to the discovery of any parallaxes exceeding 0″·20, but a large number of parallaxes between 0″·10 and 0″·20 were found.

Before the completion of this programme a more exhaustive investigation on a number of stars of special interest was commenced. The stars included stars with very large proper motion but uncertain parallax values, certain second-magnitude stars, stars previously observed whose parallax values were either exceptionally large or negative, additional large proper-motion stars, selected stars in the Pleiades, for the determination of the parallax of the group. The programme comprised 35 stars and the observations were shared between Chase, Smith and Elkin. Upon the conclusion of this

programme, Elkin retired in 1910 at the age of fifty-five years owing to ill-health.

The parallax observations with the Yale heliometer made by or under he direction of Elkin had thus comprised the 10 northern first-magnitude stars, several second-magnitude stars with unknown or unreliable parallax values, practically all stars in the northern hemisphere with proper motions exceeding 50″ per century, and various stars of particular interest. Before the application of photography, observations with the heliometer provided the most accurate method available for the determination of stellar parallaxes, and the Yale results increased several fold the knowledge of stellar distances as established at that time. When the length of time required to obtain observations with the heliometer is contrasted with that required by modern photographic observations for stellar parallax, and when the length of the reductions is considered, the amount of work done by the small staff at Yale during Elkin's association with the observatory is sufficient tribute to his zeal and enthusiasm. It was perhaps appropriate that his retirement should have come at a time when the photographic method of determining stellar parallaxes, developed mainly by Schlesinger who was later to become Director of the Yale Observatory, was about to supersede the heliometer and to render it an instrument with little more than historic interest.

Besides his work with the heliometer, Elkin was greatly interested in the photography of meteors. He set up at New Haven a polar axis upon which he mounted six cameras with axes inclined to each other but pointed at neighbouring portions of the sky. A similar installation with four cameras was set up several miles north of New Haven so that the simultaneous photography of meteors in this way would yield their distances from the stations. Elkin was able to gather only the first-fruits of this research before ill-health made it necessary for him to discontinue the work.

For their stellar parallax observations, Elkin and Chase were awarded the Lalande Prize of the French Academy of Sciences in 1908, Smith being given honourable mention at the same time. In 1893 Elkin received the honorary degree of Master of Arts from Yale University, and in 1911 the University of Christiania conferred upon him an honorary Ph.D. He was elected an Associate of the Royal Astronomical Society on 1892 November 11. He was elected to the American National Academy of Sciences in 1895 at the age of forty years, an early age at the time when the membership of the Academy was limited to one hundred.

Elkin married in 1896 Catherine Adams, the daughter of Dr. Daniel L. Adams, who survives him. She devoted her life to his care, and it is owing to this care that he reached the age of seventy-eight years, in spite of more than thirty years of illness. After his retirement, Elkin found it necessary to give up all astronomical work and even to deprive himself of the pleasure of talking over scientific subjects with his colleagues. He found interest and recreation in music, colour photography and motoring. He was an accomplished linguist, speaking and reading French and German with as great a facility as he did English and being proficient in Spanish and Italian.

H. S. J.

PROCEEDINGS OF OBSERVATORIES

The following reports of the proceedings of observatories during the past year have been received from the respective Directors, who are alone responsible for them.

Royal Observatory, Greenwich
(Director, Dr. H. Spencer Jones, F.R.S., Astronomer Royal)

Transit Circle.—The work on the zone catalogue of stars between the equator and declination $+24°$ has been continued. The number of transits observed during the year was 12,624, including 157 of the Sun and 98 of the Moon.

The copy for press of the *Second Greenwich Catalogue* for 1925 was completed during the year. It is based on observations extending over the period 1922 January to 1930 December, and contains places and revised proper motions for 1950 stars in Boss's Catalogue and for all stars brighter than $8^{m}.0$ between declinations $+32°$ and $+64°$. The catalogue is being reproduced by photolithography from a typed copy.

The reductions of the observations for the current zone catalogue are in hand.

Cookson Floating Zenith Telescope.—The numbers of plates taken for the determination of variation of latitude were :

January—18	May—21	September—20
February—9	June—25	October—18
March—30	July—26	November—7
April—15	August—24	December—12

Four additional plates were taken for the determination of scale.

Preliminary values of the variation of latitude at Greenwich in 1932 were published in the *Monthly Notices* for 1933 March. In addition to the 1932 values a diagram was published exhibiting the variations throughout the twenty-one years of observation with the Cookson telescope. Attention was drawn to the small range of variation from 1925 to 1929, which suggests a damping of the natural period followed by a fresh start.

28-inch Refractor.—340 measures of 216 double stars were secured. Arranged according to separation they are :

Under $0''.5$	123	observations
$0''.5 - 1''.0$	104	,,
$1''.0 - 2''.0$	75	,,
Greater than $2''.0$	38	,,

26-inch Refractor.—The number of plates obtained suitable for the determination of stellar parallax was 1246. 1132 plates were measured.

The parallaxes of 37 stars were published in the *Monthly Notices* for November.

The publication by photolithography of *Observations of Stellar Parallax*, vol. ii, is in progress. This volume contains the parallaxes of 251 stars. Its introduction gives, *inter alia*, discussions of the distribution of the stars according to parallax, and of their absolute magnitudes when grouped according to spectral type and proper motion.

30-*inch Reflector*.—The work on colour temperatures has been continued. Attention has been concentrated on a further programme of absolute observations, which were undertaken for the purpose of re-determining the zero point of the Greenwich standard system. The comparison standard used was an Osram uniplanar tungsten filament vacuum lamp, which was calibrated at the National Physical Laboratory. The spectrum of this was photographed, with a laboratory spectrograph, on plates which had been previously exposed on stars with the telescope. This procedure involved a frequent determination of the difference in the transmissions of the two optical trains. The comparison was effected with the aid of an acetylene burner whose spectrum was successively photographed with the telescope (the burner being then mounted on the roof of the Octagonal Building) and with the laboratory instrument. Apart from this, the programme followed in general detail the methods previously employed. 18 plates were exposed on stars on 12 selected nights, and 29 plates were taken on 12 nights for comparison of optical trains. 33 plates were taken for the determination of filter absorptions and other auxiliary quantities. All the plates have been measured, and the reductions are in hand.

In addition, 61 comparisons of 26 stars with standard stars have been secured.

Photoheliograph.—The Sun was photographed on 280 days at Greenwich and on 339 days at the Cape. There are 6 days not covered by either series, but plates for these dates are available from Kodaikanal.

The mean daily area of sunspots, corrected for foreshortening, for 1933 was approximately 90 millionths of the Sun's hemisphere. The published values for 1924–32 are 276, 830, 1262, 1058, 1390, 1242, 516, 275 and 163.

A summary of areas and positions of spots and faculæ in 1932 was published in the supplementary number of the *Monthly Notices*.

Sunspot numbers have been supplied quarterly to Zurich.

Spectrohelioscope.—Observations were made on 196 days, and include measures of radial velocity of 84 dark $H\alpha$ flocculi associated with sunspots and 308 measures on dark flocculi not associated with sunspots. 112 measures were also made on areas of bright flocculi.

The results for 1932 are given in a paper which was published in the *Monthly Notices* for 1933 January. This paper includes a list of eruptions of unusually bright $H\alpha$ flocculi and a table which gives measures of light intensities of bright flocculi. The measures were made with an optical wedge mounted between the viewing eyepiece and the rotating prisms of the spectrohelioscope.

Clocks and Time-Service.—Observations for clock correction were made

with the small reversible transit "B" on 21 nights up to April 5, and with transit "D" on 98 nights from April 13 to the end of the year.

In July a tape chronograph was substituted for the barrel chronograph previously employed for recording the small transit observations; in August the electro-mechanical relay used in the recording circuit was replaced by a thermionic valve system. These changes were made in order to reduce the time-lag in recording the signals from the transit instrument. Creed relays have been installed on all circuits from the standard sidereal clock.

The free-pendulum clock, Shortt No. 11, has been used as standard sidereal clock throughout the year. Comparisons have been maintained between this clock and No. 3, with the exception of three short periods due to impulse failure of No. 3.

The mean time free-pendulum, Shortt No. 16, has controlled all mean time-signal distribution, including wireless time-signals from Rugby and the B.B.C. stations, and the hourly telegraphic time-signals to the G.P.O.

Daily registration has been maintained of wireless time-signals received from Rugby, Nauen and Bordeaux, and whenever possible from Annapolis.

Some preliminary work on the determination of the lag in reception of wireless time-signals has been carried out by means of an oscillograph of the Duddell type lent by the Professor of Physics, Royal Naval College, Greenwich. The results give a mean correction of $-0^{s}\cdot010$ to the times of signals from Rugby, Nauen and Bordeaux, as recorded with the existing chronograph.

The International Longitude Programme, 1933.—The Royal Observatory took part in the longitude programme, organised by the International Astronomical Union, in repetition of the programme of observations made in 1926. During the period September 15 to December 15 special steps were taken to secure as many observations as possible with the reversible transit "D," the special list of stars recommended by the International Astronomical Union being used as far as possible. Observations were secured altogether on 44 nights during the three months. Three observers obtained observations and it was found that marked and consistent personalities appeared with an extreme range of 0·05 sec. The probable error of a single clock error is $\pm0\cdot01$ sec., both from internal evidence and also when the individual clock errors (after correction for relative personalities) are compared with the adopted curve. The transit observations were compared with the free-pendulum clock, Shortt 11, which maintained a fairly steady performance, the greatest departure from the adopted parabola giving the best fit to the observations being about 0·02 sec. Some small irregularities in the behaviour of the pendulum were well shown up by the abundant transit observations at certain favourable periods of fine weather. The observations are now being discussed.

Opposition of Eros, 1930–31.—The measurement of plates taken in conjunction with the Eros programme is proceeding. The Greenwich series of plates taken for the purpose of obtaining positions of secondary comparison stars for use in the reduction of photographs of Eros obtained with

long-focus instruments has been measured. The measurement of the corresponding series of Cape plates, which had been forwarded to Greenwich, is in hand. In all, 82 plates involving some 5000 stars were measured during the year. The reductions are proceeding.

With regard to the plates exposed on Eros, the Greenwich series taken with the 26-inch refractor, consisting of 160 plates, has been measured. The Radcliffe series of 52 plates which had been sent to Greenwich has also been measured. The reductions of these measures must necessarily be postponed until definitive positions of the comparison stars are available.

The Eros plates were measured with a new long-screw micrometer constructed by Messrs. Adam Hilger. The comparison field plates are being measured against a réseau, and the errors of the réseau have been determined with the long-screw machine.

Printing.—The volume, and separate parts, of *Greenwich Observations* for 1931, and also volume vi of the *Greenwich Astrographic Catalogue* have been distributed. The final proofs of *Greenwich Observations* for 1932 have been passed. The reproduction by photolithography of *Observations of Stellar Parallax*, vol. ii, and of the *Second Greenwich Catalogue of Stars* for 1925·0 is in progress.

New Instruments and Buildings.—The erection in its building of the new 36-inch reflecting telescope is practically complete. The instrument and copper-covered dome were constructed and installed by Messrs. Grubb, Parsons & Co. The building was erected by the Civil Engineer's Department of the Admiralty. A slitless spectrograph of the type at present used in conjunction with the 30-inch reflector is being constructed by Messrs. Adam Hilger. The design of a slit spectrograph is under consideration. The whole of this installation is the gift of Mr. William Johnston Yapp.

Satisfactory progress has been made with the construction of the new transit-circle by Messrs. Cooke, Troughton & Simms. The building for this instrument is in course of erection.

Miscellaneous.—Sir Frank Dyson, K.B.E., retired on 1933 February 28 from the post of Astronomer Royal which he had occupied with great distinction for more than twenty-two years. During this period the work of the observatory was developed in many new directions.

Dr. J. Jackson left on 1933 February 28 to take up his appointment as H.M. Astronomer at the Cape.

Dr. R. v. d. R. Woolley was appointed to succeed him as a Chief Assistant on 1933 June 1.

Mr. Jolly of the Ordnance Survey Department, and Mr. Bullard of the Department of Geodesy and Geophysics, Cambridge, made some further gravity observations at the observatory in May.

Dr. de Graaf Hunter, formerly Director of the Geodetic Branch of the Survey Department of India; Dr. E. Stenquist of the Upsala Observatory and Dr. P. S. Lall of the Punjab University Observatory studied some of the work of the observatory during the year.

Royal Observatory, Edinburgh
(*Director, Professor R. A. Sampson, F.R.S., Astronomer Royal for Scotland*)

The Great Reflector in the East Dome has been devoted to obtaining spectra of a variety of stars, especially variables. The spectrograph has been used as a 2-prism instrument, with the middle camera. With this, the whole spectrum between λ 3750 and λ 6700 occupies a space of about $2\frac{1}{2}$ inches, and is taken on one film. Formers are introduced into the plate-holder in order to bend the film so as to secure sharp focussing throughout this length. A number of these spectra have been reproduced with the photometer.

In the West Dome, the readjustment of the lenses of the camera being completed and the images being now passed as satisfactory, a number of duplicate plates, 16 cm. × 16 cm., have been taken of different regions of the sky, with about 30 minutes exposure. It is intended to examine these with a blink microscope. The designs for this blink microscope have been prepared by Dr. E. A. Baker, and he is supervising the construction, which is well advanced. Many of the parts are being made in the observatory.

With regard to the clocks, the new case obtained for Shortt No. 4 commenced to leak at a slow rate. The cause of this was found in lack of flatness of the upper face of the case, where it was sealed to the glass dome. The fault was fairly large. A tool was made and the face ground down without dismounting the clock. The sealing now holds.

In connection with the world longitude scheme, for which special signals were sent during the period beginning of October to middle of December, a special effort was made to lose no opportunity of determining and comparing the time. In this the weather was for the most part favourable, and the interruption of a few days of the going of Shortt No. 4, for the reason stated above, unfortunate. Besides the transit-circle, time was determined with a Bamberg reversing transit, which had been acquired and adapted. Adaptation included the construction of a hut and pier, and wires led for illumination to the Wetzar chronograph, and arrangements for an impersonal micrometer applied to the instrument. The last was moved by hand. It is considered a better plan to have a mechanical drive, but there was not time to arrange for this. Plans for it are now being prepared.

The manuscript of the astrographic plates −38°, −39°, −40°, taken at Perth, W.A., and measured here, has remained unpublished, although numerous efforts have been made to produce it. At the meeting of the I.A.U., held at Cambridge, U.S.A., in 1932, the President of the Commission secured a substantial vote in contribution to the purpose, and this is now under consideration by the Scottish Office. No final answer has been received so far.

The routine occupations of the observatory have proceeded as heretofore. The scientific staff is unchanged.

Royal Observatory, Cape of Good Hope
(Director, Dr. J. Jackson, H.M. Astronomer)

Reversible Transit-Circle.—The number of transits observed during the year was 12,078, including 202 of the Sun, 98 of Mercury, 132 of Venus and 8 of Vesta. As there were a number of stars in the programme commenced in 1925 for stars brighter than $7^{m}\cdot5$ and south of decl. $-30°$ which had not been sufficiently observed, the instrument was used in the months of June to August in securing 1487 additional observations of stars in that programme. The other observations relate mainly to stars between the equator and decl. $-30°$ brighter than magnitude 7·5. The total number of observations in zenith distance was 11,439.

72 observations of polar stars more than 5° from the pole were made with the travelling wire by the same method as is used for equatorial stars, instead of the usual method of driving the wire rapidly across the field of view and registering the time of transit of the wire over the star by a hand tapper.

In October and November, when the international longitude programme was in progress, 310 observations were made of the special list of stars between the equator and $+20°$, using a reversing eyepiece in both positions for each star.

In the course of the year the instrument was reversed 18 times.

Current reductions are well advanced, the ledgering being completed to 1932 March 23. The computation of tabular places of the Sun and planets is complete to 1931 December 31.

8-inch Transit-Circle.—During the year 1562 transits were observed. The observation of reference stars for plates taken with the wide-angle lens in the zone $-30°$ to $-35°$ was completed in November. In October and November 185 observations were secured of the special list of longitude stars.

Observation of the new catalogue of reference stars for the zone $-35°$ to $-40°$ was commenced in December and 413 observations were secured.

Zone Observations.—The wide-angle lens camera was in use on 33 nights; 30 plates in the zone $-30°$ to $-35°$ were taken. These plates complete the photography of this zone, the overlap in right ascension allowing each star to be photographed on at least 2 plates. As the plates barely cover 5° in declination, it was considered advisable to have a few plates overlapping in declination, and 6 plates were taken centred at $-35°$. As the form of the images had become much worse, some out-of-focus plates were taken. That the relative position of the components had shifted was confirmed by reflected images from the various glass surfaces of an illuminated point in the axis of the lens. The lens has been returned to the makers for re-adjustment. Seven polar trial plates were taken.

In view of the amount of work which has to be done with this instrument, it has been decided to measure a few of the plates to see what accuracy they yield and how the results from overlapping regions agree. Two plates, each

with over 300 stars in the Cordoba Zone Catalogues, have been measured for this purpose.

Victoria Telescope.—The instrument was in use on 250 nights during the year on work connected with stellar parallax. 2040 plates were obtained for the regular programme, 92 for proper motion in declination (after a lapse of at least 5 years from the first plate), and 91 preliminary plates for selection of comparison stars in new regions and ultimate use in determination of proper motions. A fifth list of parallaxes was published in the *Monthly Notices* for December, bringing the total number of published parallaxes to 500. By the end of the year 40 further parallaxes had been determined.

The copy for press of the detailed results for the first 216 stars is nearly completed. For all except 11 regions the plates for proper motion in declination have been measured. A number of plates have been taken of the south polar area and of Kapteyn area No. 97 for determination of the magnitude reduction made by the various openings of the occulting shutter and by the filter. The smaller shutter openings give a considerably greater reduction than is computed geometrically. The magnitudes of the reference stars will be determined from measurement of diameters in conjunction with the adopted magnitude of the parallax stars and the reduction of the shutter and filter.

Astrographic Telescope.—The instrument was in use on 35 nights. 17 plates were taken with an objective grating, of stars in the path of Eros during its close approach in 1931, for the determination of effective wave-lengths. As plates of Eros taken during the opposition of the present year may be of special value in the determination of the solar parallax from perturbations of the planet by the Earth during its close approach in 1931, an attempt was made to photograph Eros over as long an arc as possible this year, and 23 plates were taken between June 29 and September 11; on some of the later plates the images are rather faint for measurement.

Five polar trail plates, 1 focus plate and 2 plates in search of new comets announced by the I.A.U. were also taken.

Heliometer.—The following observations were obtained of major planets near the time of opposition :—

Mars	56	observations in	distance	on 7 nights.
,,	28	,,	,, position angle	,, 4 ,,
Jupiter	70	,,	,, distance	,, 7 ,,
,,	16	,,	,, position angle	,, 2 ,,
Saturn	50	,,	,, distance	,, 5 ,,
,,	20	,,	,, position angle	,, 3 ,,
Uranus	88	,,	,, distance	,, 6 ,,
Neptune	72	,,	,, ,,	,, 7 ,,

These observations are being continued at least till their accuracy has been tested against photographs taken with the wide-angle lens, with a neutral filter (when necessary) to reduce the brightness or density of the image of the planet approximately to that of the comparison stars.

Occultations.—The following occultations of stars by the Moon have

been observed: 17 disappearances at dark limb, 12 reappearances at the dark limb, 3 disappearances at the bright limb and 1 reappearance at the bright limb.

Photoheliograph.—706 photographs of the Sun were obtained on 339 days. Visual observations for zero of position angle were made weekly. The original negatives up to 1933 November 11 and the duplicates up to 1933 November 4 have been sent to Greenwich for measurement and preservation.

Proper Motion of Stars in the Cape Astrographic Zone $-40°$ *to* $-52°$.—As is well known, each star should occur on at least 2 plates, and the different values obtained can be utilised to determine the errors due to position on the plate. Specially valuable data were obtained from the sliding overlap of the plates centred at $-48°$ and $-49°$, the former having 6 plates to the hour, the latter 5. It was found that there was no appreciable magnitude correction, but that there was a definite position correction. The form of this correction indicated that it could be nearly all explained by a change in tilt of the plates between the two epochs. When a star was measured on two plates the resulting mean correction was in general small enough to be neglected. In a few cases, especially when a star appears on one plate only, as in the extreme zones, the correction has been applied. It has been found possible to keep results of measures made over nearly the whole of the plates, only stars in the corners of the plates where the sum of the measures of the co-ordinates exceeded 100′ have been rejected.

The general work of reduction, including the computation of precessions and secular variations for faint stars not in the Cape Zone Catalogue, has been continued.

Opposition of Eros, 1931.—The work of measurement of the plates taken with the astrographic telescope has proceeded steadily during the year. 380 plates were measured, half of them in both right ascension and declination and the other half in right ascension only. Standard co-ordinates for all plates have been computed, and the checking is almost complete. The reductions, including the application of second-order refraction, are practically up to date with the measuring.

The G.C.T. of exposures have been prepared for most of the plates measured and, now that the final ephemeris has arrived, it will be possible to proceed with the calculation of tabular places and parallax factors.

Time-Service.—The adopted longitude of the 8-inch transit-circle was changed on January 1 from $1^h\ 13^m\ 54^s{\cdot}70$ to $1^h\ 13^m\ 54^s{\cdot}60$ east of Greenwich. The ceiling fan in the clock chamber has been altered to run continuously instead of only at times of heating, thus giving a more uniform temperature throughout the clock room. The heating power has been reduced to one-eighth of its previous amount, so that the heating is spread over a longer interval. The temperature is now maintained at approximately the same temperature summer and winter, but the range allowed by the thermostat, $73°{\cdot}8$ to $76°{\cdot}3$, is rather large.

The sidereal standard clock Shortt No. 10 ran well throughout the year and the decrease in gaining rate has been small, only about $0^s{\cdot}06$ in the

daily rate. The mean time standard Shortt No. 27 gave a good deal of trouble and had to be replaced for some time by Dent.

The Belin emitter, which emits time-signals on the ONOGO system from Slangkop at 21^h G.C.T., behaved very erratically in the winter and gave a great deal of trouble, but is now functioning well. The last six dots of the ONOGO system at 17^h and 20^h S.A.S.T. were used up to the end of October by the African Broadcasting Co. as a time-signal. In view of the failures of the Belin emitter, the Molyneux mean time clock, which was formerly used in connection with the seismograph and which performs remarkably well, was fitted with electrical contacts for sending out six dots at 13^h, 17^h, 18^h, 19^h, 20^h, 21^h S.A.S.T., and since October 31 it has acted perfectly. A hand-switch is provided so that, if necessary, the six dots can be sent automatically at the end of any minute.

Normally the only time-signals observed are those from Bordeaux at 8^h G.C.T. and from Rugby at 10^h G.C.T. These were observed on 252 and 266 days respectively. During the special longitude operations of October and November a special effort was made to observe other signals, especially those from Annapolis. The following were observed :—

Annapolis	5^h	on 37 days.
,,	8^h	,, 12 ,,
Rugby	18^h	,, 42 ,,
Bordeaux	20^h	,, 30 ,,

As already mentioned, the special longitude stars were observed with both transit instruments.

Meteorological Observations.—The special observations taken in connection with the International Polar Year were continued to August 31. Thereafter the observations were confined to 8^h 30^m, 12^h 46^m and 21^h South African Standard Time. The results are telegraphed daily to the Meteorological Office, Pretoria. A monthly report is sent to the Meteorological Office, London.

Miscellaneous.—Dr. H. Spencer Jones relinquished the office of H.M. Astronomer last February on his appointment as Astronomer Royal.

Armagh Observatory
(*Director, Rev. W. F. A. Ellison*)

Observations of the planets were made as occasion allowed, principally with the 10-inch Grubb equatorial ; sometimes, when the seeing was not good enough for the larger instrument, with the 6-inch. The opposition of Mars in the beginning of the year was an unfavourable one ; seeing was seldom good, and only one really good drawing was obtained. The white spot on Saturn was observed with the 6-inch soon after its discovery, and was followed as often as weather permitted and its changes noted. The 18-inch reflector was used for various faint objects and for observation of stellar spectra, for which it is well adapted. The 6-inch is mainly used for the Sun and Moon (for which indeed it was constructed by the Director), and

for giving views of the heavens to interested visitors when weather permits. Transits are taken from time to time, to check the rate of the large transit clock. This would be done more frequently but that the condition of the transit shutters leaves much to be desired. The instrument itself is in good order. The great meteoric shower of October 9 was seen under ideal conditions, the sky being of an unusual clearness, just after the passing of a rainstorm. Special attention was given to the determination of the radiant, which was fixed with great accuracy by means of numbers of stationary meteors. The area fixed agreed exactly with that published in the November number of *L'Astronomie*, p. 512.

The climatological work has been carried on as usual. The highest temperature recorded during the year was 82°·0 on July 5, and the lowest 19°·5 on January 18. The rainfall amounted to 20·56 inches on 177 days, a total nearly 12 inches short of the average of 100 years.

Cambridge Observatory
(*Director, Sir A. S. Eddington, F.R.S.*)

Photoelectric observation of variable stars, begun in 1932 October, has been continued throughout the year and has occupied the whole time of the observers. The results continue to be satisfactory, but at present only bright stars can be measured. Algol was observed on 37 nights, β Lyræ on 41 nights and δ Cephei on 17 nights. For β Lyræ the secondary minimum is well observed, but the principal minimum has almost always coincided with cloudy weather. Seven other variable stars have been under observation.

A paper by Dr. Smart on photoelectric observations of the intensity of twilight has been published (*M.N.*, **93**, 441). Considerable attention has also been given to the determination of the extinction correction depending on the difference of Z.D. of the variable and its comparison star. This involves the determination each night (or portion of a night) of an extinction factor depending on the clearness of the sky. It is found that the instrumental conditions remain so steady that the changes of extinction factor from night to night can be determined from the changes of the measured brightness of the comparison star (*M.N.*, **94**, 115).

A new photographic object-glass has been ordered for the Sheepshanks telescope to be used interchangeably with the present photo-visual object-glass. It is hoped that this will increase the light power considerably, especially in the ultra-violet, and so benefit the photoelectric observations.

No photographs have been taken, but 4 fields of photographic proper motions have been measured.

Mr. R. H. Stoy has been working on problems connected with the physical condition of the planetary nebulæ (*M.N.*, **93**, 588). He left in the summer to hold a Commonwealth Fellowship at the Lick Observatory. Mr. J. A. Edgar, B.A., has published an investigation on the pulsation theory of Cepheid variables (*M.N.*, **93**, 422). He has also been working on the problem of galactic rotation from the dynamical point of view.

Mr. M. H. H. Walters, B.A. (who left in the summer to hold a Fellowship

at Princeton), has been working on the dynamical problems of star clusters, Mr. C. G. Pendse, B.A., on Saturn's rings, and Mr. R. A. Lyttleton, B.A., on dynamical astronomy, under the supervision of Dr. Smart.

Solar Physics Observatory, Cambridge University
(Director, Professor F. J. M. Stratton)

There are no changes of staff to report. Professor Wilson has continued to supervise work on meteorological physics and with the expansion chamber. Mr. E. C. Halliday has been examining cloud-tracks during thunderstorms, producing the expansions by means of the lightning discharge. Mr. W. A. Macky has endeavoured unsuccessfully to detect "runaway" electrons in overhead thunderstorms by balloons carrying photographic plates; while Senora Vallejo of the Spanish Meteorological Service has been studying the point-discharge current in disturbed weather conditions. Mr. J. A. Ratcliffe and other members of the Cavendish Laboratory have continued their investigations of the ionosphere. Dr. R. v. d. R. Woolley and Mr. R. H. Stoy, Isaac Newton students, were working at the observatory until their departure to the Royal Observatory, Greenwich, and the Lick Observatory respectively. Mr. A. D. Thackeray, Sheepshanks Exhibitioner, has continued his work on the intensities of the lines of *Fe*, *Mg* and *Na* in the green region of the spectra of late-type stars. Mr. J. A. Edgar, Isaac Newton student, has commenced a spectro-photometric study of δ Cephei.

Buildings and Instruments.—A temperature-control room has been built inside the laboratory round the mounting of the Rowland grating. This has led to a great improvement in the quality of spectra requiring long exposures. A thermostat control by the Cambridge Instrument Company has been fitted to the spectrograph of the Newall telescope resulting in a very marked improvement in the stellar spectra; also a thermostatically controlled developing tank has been installed in an additional dark room.

The K side of the spectroheliograph has been remodelled to eliminate distortion of the image, the number of reflections being reduced from two to one. Two 6-inch 45° prisms recently refigured by Messrs. Hilger are now used for dispersing the beam. The two collimating slits for $H\alpha$ and K respectively have been mounted on a sliding stage to facilitate the change over between the two instruments. The oil clepsydra of the spectroheliograph and the driving clock of the 18-inch siderostat have been overhauled and cleaned. Also the 12-inch photovisual lens has been cleaned; it is satisfactory to find that no apparent deterioration of the glass surfaces has taken place during the thirty years of its use. The rotating prisms of the spectrohelioscope have been adjusted and the quality of the observations considerably improved.

Electric motors have been installed for driving round the roof and platform of the Newall dome and for raising and lowering the shutters.

Solar Work.—During 1933 spectroheliograms of the Sun's disc in $H\alpha$ light have been obtained on 81 days and of the limb on 72 days. Only a few experimental plates have been taken in K light during the progress

of reconstruction. No observations of interest with the spectrohelioscope are to be recorded. Spectroheliograms have been received from the Director of the Kodaikanal Observatory, India, and photoheliograms from the Astronomer Royal for record purposes and for character figures of solar activity for inclusion in the *Bulletin* issued by the I.A.U.

137 spectrograms of the Sun for line-contour work were secured by Dr. Woolley with the McClean Littrow spectrograph, a set of four 2-inch prisms (3 of 60° and 1 of 30°) having replaced the grating formerly used in this instrument.

Stellar Work.—161 stellar spectrograms were secured with the Newall spectrograph on 78 nights. These have been obtained for line intensities and later for a study of stellar rotations by Professor Carroll's method. For this work the 4-prism spectrograph has been taken into use. Plates are being reduced at Aberdeen. As a first step towards standardisation of line-intensities secured by different instruments, a number of measures of line profiles from plates of γ Ursæ Majoris taken with both 2 and 4 prisms have been sent to the Victoria Observatory, Canada.

With the Huggins refractor 114 spectrograms in the green region were secured on 46 nights. The quartz spectrograph was mounted on the Huggins reflector by Mr. Stoy.

The 3-foot Common reflector was used on 53 moonless nights ; 83 plates, mostly with double exposures, were obtained for the determination of magnitudes of elliptical nebulæ ; 31 plates were measured and reduced. The average error appears to be slightly over $0^{m}.1$ per plate.

Meteorological Physics.—In addition to the investigations by non-members of the staff recorded above, work has continued on the electric fields of thunderstorms, and full use has been made of the improved facilities now available. A large amount of material is being analysed.

Laboratory Work.—The improved spectrograms of the pole of the iron arc are being measured. Several new multiplets of *Fe* II have been identified. In addition to various necessary tests of optical apparatus, a comparison has been made between the reflecting powers of speculum, silver and aluminium surfaces, with a view to the possibility of using aluminium generally to coat the 15 glass mirrors in regular use in the observatory instruments.

Dunsink Observatory
(*Acting Director, Mr. Charles Martin, M.A.*)

The time-service to Dublin has been continued as in previous years.

The observatory has been used mainly for teaching purposes, students being welcomed for instrumental instruction and observational work.

Durham University Observatory
(*Observer, Frank Sargent*)

The routine programme of variable star observations has been carried out as in previous years and certain planetary phenomena have been also noted.

Daily meteorological observations have been recorded. The Milne-Shaw seismograph has been in regular use and the analyses of the main earthquake disturbances have been forwarded to the International Bureau at Oxford.

The apparatus for continuous observation of atmospheric potential gradient and earth-air current is now installed and preliminary observations are being made.

Liverpool Observatory and Tidal Institute

(*Director, Professor J. Proudman, F.R.S.; Associate-Director, Dr. A. T. Doodson, F.R.S.*)

Tidal predictions of high and low water have been made for seventy places; of hourly heights of water for one place; and of times of slack water for three places. Fourteen years' records of tidal observations from seven places have been analysed.

Research has been carried out on methods of tidal analysis and prediction, on annual variations of tidal constituents, on the dynamical theory of ocean-tides and on the observation and analysis of earth-tides; also on the frequency-distribution of rainfall.

An electrically operated tide-gauge, in which the recording element will be housed in the observatory, is under construction, and a new thermograph, with two mercury-in-steel elements as wet and dry bulbs, has been installed.

The regular meteorological and seismological services of observation and transmission of information, and the firing of the time-gun, have been continued.

Dr. Doodson has been elected to a Fellowship of the Royal Society.

University of London Observatory, Mill Hill, and University College Observatory

(*Director, Professor L. N. G. Filon, C.B.E., F.R.S.; C. C. L. Gregory, M.A., Wilson Observer*)

The administration of the University Observatory was taken over by the University of London on August 1, on expiry of the period of its first five years of administration by University College.

Wilson Reflector.—Only 15 plates were obtained with the reflector during the year, as it was used mostly for experimental work in testing various methods of stellar photometry. At the request of the Astronomer Royal one plate was taken of the newly discovered small planetary nebula. The telescope was used in all on 30 nights.

Rowland Grating Spectrograph and 8-inch Cœlostat Telescope.—Little use was made during the year of this equipment for spectroscopic purposes, but the cœlostat telescope was used in connection with the experimental work on photometry, which occupied most of the available time this year.

Fry 8-inch Refractor.—This instrument was used on 141 nights. Thirty-one observations were made of the Sun, and 32 plates were taken by Mr. Frank Robbins with a small portrait-lens camera, kindly loaned for this purpose by Mr. Sellers.

Measurement of Plates.—Miss White completed the measurement of the Wilson region in the neighbourhood of cluster M37 (N.G.C. 2099) and the results were published in *M.N.*, **93**, 647, 1933.

Occultations.—Observations of occultations were made throughout the year, and the third list was published in *M.N.*, **94**, 91, 1933.

Miscellaneous.—A number of copies of the *Monthly Notices* were presented to the observatory by the Council in order to complete a set of volumes which had been given to the observatory by the Wilson Observer.

Visitors.—There were 197 visitors during the year.

University College Observatory.—The work, which is mainly instructional, has been carried on as in previous years. At the beginning of the year an 8-inch equatorial refractor by Cooke was presented to the college by the Trustees of the late Mr. Johnson, of Liverpool, through the kindness of the Rev. Norman Edge. This instrument was incomplete, a number of the parts of the mounting having been mislaid. These were made good in the college workshops, castings being supplied by George Wailes. This instrument was mounted in the summer in the Chadwick Observatory in place of the 4-inch refractor, the mounting of which had for some time been unsatisfactory through wear.

Radcliffe Observatory, Oxford
(*Director, Dr. H. Knox-Shaw, Radcliffe Observer*)

The weather in the early part of the year was more favourable than usual, and the observational programme on proper motions in the Selected Areas was completed during the summer. It was begun in 1909. The catalogue containing the proper motions of some 32,000 stars has gone to press, the introduction to the volume is nearly ready for press, and it is hoped that the whole will appear during the current year.

The question of the future of the observatory is still *sub judice*. The opposition of the University of Oxford to the proposed removal to Pretoria has necessitated the filing of further affidavits in support of the proposal, with consequent postponement of the hearing of the case. The observatory is due to vacate its present site in 1935 June.

University Observatory, Oxford
(*Director, Professor H. H. Plaskett*)

Equipment.—The outstanding event of the year has been the grant by the University of £2700 for the construction of a solar telescope, solar spectroscope and a registering microphotometer. The major part of this grant was made in May, and contracts for the solar telescope and for the optical parts of the spectroscope were signed in July with Sir Howard

Grubb, Parsons & Co., and with Adam Hilger Ltd., respectively. The solar telescope, which is to be of the tower type with a Cassegrain optical system, will have its five mirrors made of fused quartz, and will be erected in one of the existing domes of the observatory. The spectroscope is to be of the Littrow type with two 60° and one 30° prisms of light flint glass with faces 9·1 in. long by 6 in. high ; the resulting dispersion will be some 3 mm. to the A. in the region of *Hδ*.

Astrophysics.—The work on the determination of the surface brightness of the centre of the solar disc was continued during the months of May to September. A technique of measuring surface brightnesses differing by as much as 1800 to 1 was fully developed, and a number of spectra satisfying these new and unusually stringent conditions of accurate spectrophotometry were obtained. Work was continued on the temperature of solar granulation. Dr. Cillié completed his investigation on planetary nuclei, and was able to show that the nucleus of N.G.C. 6826 was a "white dwarf" with a mean density of 1000 grm. per c.c. Dr. Zanstra, a volunteer research worker at the observatory during the summer months, carried out a study of the motions of diffuse matter in interstellar space.

Astrographic Catalogue.—Mr. Bellamy continues to push forward the work on the Potsdam zones +32° and +33° at an increasing rate. Sixty satisfactory plates were obtained during the year in the two zones, and 43 were measured and completely reduced. The work is nearly one-third completed.

Seismology.—Adequate support for the International Seismological Summary for the next three years has been assured by the action of the University, the International Union of Geodesy and Geophysics, and the Seismological Committee of the British Association. In spite of the increasing volume of work, Mr. Hughes and Miss Bellamy completed the reductions of epicentres for the last three quarters of 1929 and for the first quarter of 1930. All four parts of the volume for 1929 were printed and distributed during the year.

Norman Lockyer Observatory, Salcombe Hill, Sidmouth
(*Director, William J. S. Lockyer, M.A., Ph.D., Major (late R.A.F.)*)

The Kensington 9-inch prismatic camera has been in regular use for photographing the spectra of selected bright Be-type stars, and 234 negatives have been secured. The Zeiss triplet lens attached to this instrument has also been used for the photography of star regions during part of the time of the exposure of the spectra. Occasional photographs have been taken with the two fixed meteor cameras which are erected near the Kensington dome. The McClean 12-inch prismatic camera has been in frequent use for photographing the spectra of the fainter B-type stars, and also for investigating spectrum variations in stars of the *β* Canis Majoris type. The number of spectra obtained was 143. Exposures with the Mond photographic equatorial were made on 16 nights, long exposures being given on each occasion, the maximum being 6½ hours. The objects photographed

were nebulæ and regions of the Milky Way. Altogether 49 negatives were secured with the four cameras.

The number of fine nights was 148, which is considerably above the average annual number (128) and is 42 more than last year. It has only once been exceeded, namely, in 1925 when the number was 168. Successful observations were made on 134 of these nights.

Work has been continued on B-type stars which show bright hydrogen lines in their spectra, and the Director has demonstrated the variability of these lines in the case of γ Cassiopeiæ (*M.N.*, **93**, 362, 619). The observations suggest a period of about four years. Work has also been continued on the spectra of B-type stars in general, from the points of view of classification, peculiarities and the determination of spectroscopic parallaxes. Some stars with short-period variations of spectrum, similar to β Canis Majoris, are also under investigation. It has been shown that 42 Camelopardalis belongs to this group, and its spectrum changes have been described (*M.N.*, **93**, 729).

A serious heath fire broke out near the observatory on April 20 and lasted from 10 a.m. to 7 p.m. It rapidly spread into the observatory grounds, and although the fire came close up to the power station and approached the McClean and Mond domes, no damage was done to these buildings as the ground around them is always kept clear. The Sidmouth fire-engine was called up and rendered material assistance. The only damage done was to the fencing round the grounds.

The battery of 60 Tudor accumulators used for lighting the observatory buildings since their foundation in 1912 has been replaced by a new set. The work was done in August by Messrs. Rawlings Bros. Ltd., London.

A notable gift to the observatory has been the presentation by Sir Francis K. McClean of a large number of valuable instruments, stellar negatives and pieces of apparatus, which originally belonged to his father and were located at Rusthall, Tunbridge Wells.

The observatory is open to the public on Wednesday afternoons, and in addition was visited by larger parties by special arrangement. The total number of visitors who attended during the year was 515.

The seventeenth annual general meeting of the Norman Lockyer Observatory Corporation was held in London on June 8.

Stonyhurst College Observatory
(*Director, Rev. J. P. Rowland, S.J., B.Sc.*)

The staff of the observatory is at present reduced, Father J. F. Fleming, S.J., having been withdrawn for other work. The usual routine work has been continued, and the meteorological, magnetic and seismological records have been maintained throughout the year, and the results forwarded to the official centres.

Observations of the solar surface were obtained on 296 days, and, by the kind co-operation of Professor W. Brunner of Zürich and Professor G. Favaro of Catania, statistics have been obtained for all but three days in

the year. Sunspot statistics have been sent quarterly to Professor Brunner for the preparation of "Sunspot Numbers" and International "Solar Character Figures." Solar activity shows a further decline towards minimum. There were 249 spotless days, as compared with 164 in 1932 and 36 in 1931, whilst the mean daily disc area in units of 1/5000 of the disc fell to 0·41, as compared with 0·81 in 1932 and 1·26 in 1931. A small group of spots belonging to the new cycle was observed on October 29 in Lat. $-32°$.

Magnetic activity, which showed a slight increase in 1932, has now declined to its lowest value so far in the expiring solar cycle, the mean ranges in declination and horizontal force being respectively 13′·4 and 57·3γ, as against 14′·4 and 62·8γ in 1932, and 13′·8 and 59·5γ in 1931.

Lunar occultations were observed when possible, and the results sent to Dr. Comrie.

Observations of transit times of the white spot on Saturn were made between August 9 and September 16, and a rotation period deduced in a paper communicated to the Society.

A watch was kept for the Leonids throughout the night of November 16–17, but none were seen.

The number of earthquakes recorded during the year was 105, of which one on March 2, having its origin off the coast of Japan, was remarkable as producing the greatest amplitude of ground oscillation ever recorded at this observatory. A local shock, which was felt over a wide area in the North of England at about $8^h\ 30^m$ G.C.T. on January 14, and had its origin in Upper Wensleydale, was made the subject of a special investigation in a paper communicated to The British Association at the Leicester meeting.

It may be of interest to put on record that the iron mast of the Dines anemograph, which is mounted on the meteorological building, was struck by lightning at 16^h on July 7. The bulk of the discharge passed to earth through the stay wires, but it appears that there was a lateral discharge from the foot of the mast in the anemograph room, which did slight damage to electric light fittings and put the observatory telephone out of action, but no structural damage was done. The mechanical shock to the building was recorded on the seismograph, and the curve ordinates on the magnetographs were instantaneously changed, the declination ordinate being increased by 4′·5 and the horizontal force by 36γ. These effects can be satisfactorily explained on the supposition that the acquired magnetic polarity of the mast was discharged by the lightning flash, thus decreasing its external field in the vicinity of the magnetographs, which are situated in an underground chamber, about 30 feet below the level of the foot of the mast and about 45 feet horizontally to the south-east.

Dominion Observatory, Ottawa, Canada
(*Director, Mr. R. Meldrum Stewart*)

Meridian Work and Time Service.—Observations with the meridian circle were continued on the regular programme of stars, the Sun, Moon

and planets until the end of August. The staff and telescopes were engaged on the work of the International Longitude measurements from then until December 15. At Ottawa clock corrections for longitude were observed with the meridian circle and with a Heyde transit kindly loaned by the Geodetic Survey. With the Heyde, the usual circum-zenithal stars and azimuth stars were observed, as well as Perrier's list of 40 equatorial stars. The regular list of meridian circle clock stars was added to the circum-zenithal and Perrier lists in the observations with the meridian circle. Observations were obtained on 50 nights. At Vancouver, a Heyde transit and a Cooke transit (remade in the observatory shop into a very efficient broken-type transit) were used. Observations were obtained on 40 nights. At both Ottawa and Vancouver personal equation machines, designed on the principle of the Naval Observatory machines, were employed. The time-signals were received regularly by the method of coincidence by extinction and also by automatic registration when signal strength permitted. Relay and signal lags were recorded on motor-driven high-speed chronographs. The time service maintained in the various government buildings was extended to include the Confederation building. Clock beats have, as previously, been sent out when requested over telephone and telegraph. Wireless time-signals were received daily from Rugby, Annapolis, Bordeaux, Nauen and Monte Grande. Time-signals were broadcast at noon daily, except Sunday, through CRCO on concert wave-length, and daily at 3 p.m. and 10 p.m. through the observatory station on wave-lengths of 90, 40·8 and 20·4 metres.

Solar Physics.—Solar spectrograms, 385 in number, were obtained in the λ 5600 region, of centre, midway and limb points, with iodine absorption spectra. About 80 solar photographs were taken. A reduction in staff necessitated the discontinuance of the work on the astronomical cycles in weather and forms of life in Canada, with the exception of the measurement of the remaining tree-sections. Preparation for publication of the earliest solar rotation material has been resumed. Time-saving tables for determining heliographic positions and components of rotational velocity were amplified and completed for publication along with a description of a graduated sphere and co-ordinate frame used for the same purposes.

The 15-inch Equatorial.—Observational work was restricted due to illness and reduction of staff, and was further hampered by exceptionally poor seeing conditions during the latter part of the year. 439 individual observations were made with the photo-electric photometer, the following stars being among those investigated : ν Eridani, 42 Camelopardalis, 43 Camelopardalis, g Ursæ Majoris, β Cephei, α Virginis and γ Ursæ Minoris. Most interesting results were obtained from the study of ν Eridani, several light-curves of this short-period variable showing marked variations of amplitude. As in former years, the telescope was made available to visitors every clear Saturday evening.

Photographic Photometry.—Work was continued on the International Cepheid programme. Over one hundred plates were obtained for the determination of the magnitudes of comparison stars, and a few plates for light-

curves. Measures were made on the comparison stars of several fields, but no fields have as yet been completed.

Seismology.—During the year 377 earthquakes were recorded at the Ottawa station, and of this number 27 were reported to the Press and 21 to Science Service at Washington, D.C. The dates of occurrence and the areas affected by the largest earthquakes registered are as follows: 1933 March 2, Pacific Ocean near Japan; 1933 March 11, Long Beach, California; 1933 April 27, Alaska; 1933 August 28, South Atlantic near Sandwich Group; 1933 November 20, Baffin Bay. The auxiliary stations at Saskatoon, Halifax, Shawinigan Falls and Seven Falls were maintained in practically continuous operation throughout the year.

Terrestrial Magnetism.—Owing to restricted appropriations, observational work was confined to the yearly redetermination of the magnetic elements at Ottawa. Investigations relating to the magnetic moment and distribution coefficient of the magnets of magnetometers used in observational work were carried out, and progress was made in the reduction to epoch of all observations made since the inauguration of the systematic survey in 1907.

Gravity.—Owing to restricted appropriations no pendulum field-work has been carried on for the last three years. Some further computations have, however, been made with the 129 stations already established, and a general report on all gravity work so far completed in Canada is in preparation.

Applied Geophysics.—In continuation of the work begun by the observatory in 1928, a magnetometric and torsion balance survey was made of an iron deposit on the Mattagami river in Northern Ontario. The survey was undertaken in co-operation with the Ontario Research Foundation and the provincial Department of Mines for the purpose of outlining the extent of the deposit which outcrops along the river bank but disappears beneath a considerable covering of clay in the area adjoining the river.

Publications.—Publications during the year included three numbers of the regular series of Publications of the Dominion Observatory, namely, Vol. x, Nos. 16, 17 and 18, *Bibliography of Seismology*. Other papers published elsewhere or issued in mimeographed form included the following: Smoothed Time-Distance Tables for a Normal-Focus Earthquake; Report on the Torsion Balance and Magnetometric Investigations of 1930; Plumb-line Deflections and Gravity Anomalies in Gaspe Peninsula and their Significance; The Foundations of Earth-Structure Theory; Two Probability Methods for the Determination of Earthquake Epicentres; Epicentral Time and Surface Structure determined for the Tango Earthquake, Japan, March 7, 1927.

Dominion Astrophysical Observatory, Victoria, B.C.
(*Director, Dr. J. S. Plaskett, F.R.S.*)

The staff of the observatory has remained unchanged during the year.

The observing weather during 1933 was the poorest since the observatory was opened over fifteen years ago. While the general average for the fifteen

years shows 202 nights with 1256 hours observing time, there were in 1933 only 169 nights with 982 hours. The number of spectra obtained, 630, shows a proportionate reduction and is less than half the fifteen-year average of 1402, the decrease being due to the observation of fainter stars. Eight of the nights were devoted to photography at the prime focus, when 123 photographs of globular clusters were obtained.

The Director and Dr. J. A. Pearce, in collaboration, have continued the discussion of the radial velocities and proper motions of the O to B5 stars, which is now approaching completion. The analysis of the radial velocities was practically complete last year, and during 1933 an exhaustive investigation of the proper motions yielded new values of the precessional constants which, when applied, gave a new determination of the rotational constant B. The revised values of the constant A and the direction to the centre l_0 obtained from the radial velocities when combined with B indicated that the distance to the gravitational centre is 10,000 parsecs in agreement with the photometric distance corrected for the effects of absorption. Vol. 5, No. 3, on the interstellar matter was distributed during the year, while Vol. 5, No. 4, "The Motions of the O to B5 Stars," which will conclude the discussion of these stars, is in preparation for publication.

Mr. W. E. Harper has practically completed the observations of the stars on the A-type programme, and has made a considerable number of plates of spectroscopic binaries for the purpose of improving the periods of previously determined orbits and obtaining the elements of new binaries. The spectroscopic orbits of the eclipsing variable H.D. 210334 and of the star H.R. 8584 were determined, the orbits of Boss 5070 and ϕ Aquilæ were revised, the periods of several others improved and provisional elements of the long-period variable VV Cephei obtained. The radial velocities of 477 miscellaneous stars of types F to M, for 105 of which no velocity has previously appeared, were prepared for publication and are now in press. A comparison of the well-established velocities among these stars with those of the Lick Catalogue indicates the Victoria velocities are 0·9 km./sec. more negative than the catalogue values.

Dr. J. A. Pearce has collaborated with the Director in the work on the O to B5 stars, and in addition has continued his investigations of the orbital elements and masses of eclipsing and ordinary spectroscopic binary systems. Spectroscopic and photometric elements of MR Cygni were obtained, indicating grazing annular eclipse at principal minimum and masses of 2·9 and 2·5 times the Sun. A revision of the spectroscopic orbits of H.D. 216014, in conjunction with Huffer's photometric elements, leads to masses of 14·3 and 12·3 times the Sun. A new determination of the rotation of the line of apsides of Y Cygni is in progress but, owing to the period being so near 3·0 days, observations over another season will be required.

Dr. C. S. Beals has completed investigation and discussion of the various features of the Wolf-Rayet spectra, and a complete summary of all the work on these peculiar objects is now in press. It contains a description of the spectro-photometric methods developed and used in the investigation to determine the band contours, with a theory of their origin. It discusses

the spectral classification, indicating two distinct spectral sequences, and the temperatures as determined by Zanstra's method. Work on the interstellar lines is being continued, indicating that the total intensities of the sodium lines are on the whole considerably greater than for the calcium lines, while the relative intensities of the two members of the sodium doublet D_1/D_2 appears to vary in different stars from 0·5 to 0·9. The existence of stellar sodium in early type stars is being studied, and traces of stellar absorption of both calcium and sodium have been found in stars as early as B1.

Dr. F. S. Hogg has continued his study of the spectra of the brighter planetary nuclei and work on the internal motions of these nebulæ is also in progress. The spectrum of Z Andromedæ has again been observed in 1933, and the changes in the spectrum of this and analogous stars has been explained by the hypothesis that the system consists of a very bright variable early-type dwarf, a giant M star, and a sparse envelope of nebular matter possibly ejected during the nova-like outburst characteristic of this type of composite star. A small slitless spectrograph interchangeable with the Newtonian plate-holder for use in spectro-photometric work and in classification of the spectra of faint stars has been designed and completed. Direct photographs of globular clusters at the Newtonian focus have been continued in collaboration with Dr. Helen B. Sawyer, who has discovered over 50 new variables and determined many periods.

Mr. S. N. Hill has continued his computational work, has prepared many graphs and charts and has assisted in photometric measurements and reductions.

During the year Vol. 5, No. 3, and Vol. 6, Nos. 6, 7 and 8, have been printed and distributed, while Vol. 6, Nos. 9, 10 and 11, are in press. Several articles in astronomical periodicals have appeared during the year, numerous lectures have been given by the staff, and the weekly seminars have been continued.

Helwan Observatory, Ministry of Public Works, Egypt
(*Director, Mr. P. A. Curry*)

Time Service.—The time service was maintained as usual, the error of the standard clock, Shortt No. 1, being determined from star transits. Rhythmic W/T signals were received daily from Bordeaux and Rugby, during the morning up to October 1 and during the evening as well for the period of the longitude operations. Nauen's 12^h G.C.T. signals were also received during October, November.

The transit instrument showed slight instability on a few occasions throughout the year ; this was made evident by a sudden change of azimuth during a night's observation. By the end of September just before the longitude operations began, this instability was found to be partly due to the lifting and reversing mechanism and partly due to the fact that the pivots were not resting uniformly in their bearings. A slight tilt of the western bearing arm, although it introduced inequality in the level readings for micrometer east and micrometer west, made the azimuth fairly stable.

141 transit observations were taken throughout the year, 68 of which were taken during October, November and the first half of December.

A personal equation machine similar to the one used in the Washington Naval Observatory and in Paris Observatory was added to the time-service equipment. An artificial star, consisting of a fine illuminated hole, was made to transit in an east and west direction by means of a vertical rotating disc having teeth cut in one half of its circumference only, which engage with an upper or a lower fixed horizontal teethed rack. The disc is driven by means of a small electric motor. A stylus, rigidly attached to the artificial star frame, breaks the chronograph circuit at suitable intervals, and an uncorrected lens of 30 m. focal length, erected on the old North collimator pier, permits the following of the star by means of the impersonal micrometer.

Details of the machine and the results obtained will shortly be published in a Bulletin describing the last longitude operations.

Reynolds Reflector.—The reflector was used on 20 nights and 21 plates were exposed on various nebulæ.

General.—The usual meteorological, magnetic, seismological and solar radiation observations were continued.

Publications.—Bulletin No. 36, on the Choice of a suitable Projection for representing the Celestial Hemisphere, was published during the year. A Bulletin describing the last longitude operations and another describing the Nebulæ photographed since 1927 are now in hand.

Nizamiah Observatory, Hyderabad
(*Director, Mr. T. P. Bhaskaran, M.A.*)

The astrographic telescope was in regular use during the year, and 178 plates have been taken with centres in the zones $+36°$ to $+39°$. 88 photographs have been measured in both positions, for the catalogue, besides 7 plates measured for the determination of proper motions. The assistance of an additional computer being available temporarily, good progress has been made with the measurements and reduction of the Eros photographs.

MS. of Vol. ix dealing with the measures in zone $+39°$ is in the hands of the printers, and the whole of the typescript, with the exception of the Introduction, has been passed for press. The printing of Vol. viii, Part 1, containing the mean residuals of the reference stars $-18°$ to $-22°$, is also in the press; it is hoped that both the publications will be ready for distribution early in 1934.

With the 15-inch Grubb refractor, observations of variable stars (most of them with faint minima) were continued and 993 estimates of visual brightness have been obtained.

Eighteen occultations of stars by the Moon—all disappearances at the dark limb—were observed and the reductions have been completed. As usual, observations with the transit instrument were made occasionally for the determination of clock corrections.

An underground room was constructed in the observatory grounds for the accommodation of the seismographs, and both the machines were removed

from their old places and re-erected on a pier of concrete in the new room in 1933 October. They have been operating without much interruption and have recorded over 121 shocks during the year.

The usual meteorological observations, including those connected with upper air, as well as the other routine duties have been maintained as in previous years.

Kodaikanal Observatory
(*Director, T. Royds, D.Sc.*)

Photoheliograms were obtained on 332 days, calcium flocculi plates on 327 days, calcium prominence plates on 303 days, *Hα* flocculi plates on 281 days, and *Hα* prominence plates on 265 days. One calcium flocculi plate for each day was sent to the Solar Physics Observatory, Cambridge, as in former years.

Under the auspices of the International Astronomical Union, prominence and *Hα* disc spectroheliograms were collected from other observatories whenever complete observations were not possible at Kodaikanal. The statistical data regarding prominences seen at the limb and by absorption on the disc are published in half-yearly bulletins.

Daily character figures of solar activity according to *Hα* bright flocculi and *Hα* dark markings have been communicated to the Observatoire Fédéral, Zürich, for publication as in previous years. Daily character figures for calcium flocculi from Kodaikanal photographs are furnished by the Solar Physics Observatory, Cambridge.

A spectrohelioscope was received on loan from Mount Wilson Observatory and is being set up.

Observations of star transits and of wireless time-signals were taken from October to December 1933 in connection with the International Longitude programme of 1933, and the observations are being reduced.

The following publications were contributed by the staff during the year :—

1. "On the Resonance Lines of Thallium and their Probable Absence in the Sun," by Dr. A. L. Narayan, *Kodaikanal Observatory Bulletin*, No. 99.
2. "The Hydrogen Content of Prominences," by Mr. C. P. S. Menon, *Kodaikanal Observatory Bulletin*, No. 101.
3. "Summary of Prominence Observations for the First Half of 1932," *Kodaikanal Observatory Bulletin*, No. 100.
4. "Summary of Prominence Observations for the Second Half of 1932," *Kodaikanal Observatory Bulletin*, No. 102.

Solar research during the year was mainly confined to microphotometric study of selected lines in the solar spectrum.

Mr. A. S. Rao, M.A., M.Sc., who was a research worker in this observatory, has been declared eligible for the doctorate degree of Madras University.

Dr. A. L. Narayan, the Assistant Director, was on leave for about two and a half months prior to Christmas.

Union Observatory, Johannesburg
(Union Astronomer, Mr. H. E. Wood, M.Sc.)

26½-inch Grubb Visual Refractor.—The number of visual micrometrical measures of double stars made during the year was 3489. Experimental work was carried out with an eyepiece interferometer and 98 measures were made. The results were very satisfactory and it was evident that, with the use of this simple accessory, it will be possible to continue the observations of certain binaries after the separation has become too small for direct micrometer measures to be made.

In continuation of the programme of observations of Saturn's satellites, instituted by the late Professor Georg Struve of Neubabelsberg, 77 measures of the satellites Enceladus and Mimas were made. Some position observations were made of the large white spot which appeared on Saturn in 1933 August.

Using a yellow screen and yellow sensitive plates, 11 plates of double stars and 52 plates of N.G.C. 3532 were obtained.

Franklin-Adams Star Camera.—During the year 550 plates were obtained with this instrument.

The distribution of the plates was as follows:—

Minor planet regions and star maps	376 plates.
Variable star regions	116 ,,
Comets	58 ,,

Comet 1932 *n* (Forbes-Dodwell) was under observation from 1932 December 18 to 1933 January 7; Comet 1933 *b* (Pons-Winnecke) was observed from 1933 May 27 to September 22. An unsuccessful search for Comet Finlay was carried out during April and May.

During the search for Comet Finlay the trail of a minor planet with an unusually large motion was found on the plates. This object was provisionally designated 1933 HH, and the early observations suggested that the planet was moving in an orbit of very small semi-axis. From a longer series of observations identity of the object with 192 (Nausikaa), which came to opposition in November, was established.

A new minor planet 1932 EB_1, discovered here in 1932, was observed again in 1933 and is now numbered and named—1241 Dysona.

During the year 396 measured positions of minor planets have been forwarded to the Astronomisches Rechen-Institut.

Occultations of Stars by the Moon.—The programme of the last few years has been maintained without alteration, and 191 occultations were observed during the year.

The results of the year's observations are as follows:—

		s	″
	1933·11	7·9	4·3
	·40	10·6	5·8
	·66	8·2	4·5
	·84	8·3	4·5
Mean for year	·59	8·8	4·8

The second column indicates the time by which the Moon has arrived too early at any longitude, and the third column the distance the Moon is ahead of its tabular longitude.

A number of occultations observed by Messrs. G. E. Ensor and H. J. F. Burroughs, both of Pretoria, have been reduced and forwarded to Professor E. W. Brown.

Union Observatory Circulars.—During the year Circular No. 89 has been distributed and No. 90 has been completed and passed for press. Fifteen southern star maps were issued with Circular No. 89.

The present state of the project is as follows:—

Maps already issued	462
Maps in hands of Government printer	31
Maps still to be prepared	63
Total	556

Miscellaneous.—Dr. H. van Gent returned to the observatory from Leiden on 1933 September 11. Professor H. Kimura of Mizusawa visited the observatory on October 18. The number of visitors to the observatory during the year was 1574.

Adelaide Observatory
(*Director, Mr. G. F. Dodwell, B.A., Government Astronomer*)

The usual routine work described in earlier reports has been continued. Latitude variation observations with the zenith telescope supplied by Dr. Kimura, President of the International Latitude Commission, were continued throughout the year, and 932 pairs of latitude stars were observed on 88 nights, the observers being Messrs. A. L. Dawson, B.Sc., and A. E. Markey. The results were sent to Dr. Kimura at Mizusawa Observatory for the investigation of latitude variation and the z phenomenon, in conjunction with those obtained at the other international latitude stations. The mean value of the latitude of Adelaide from the previous year's observations was $-34^\circ\,55'\,36''{\cdot}02$. The value obtained in earlier years from other observations (referred to the same site, viz. that of the zenith telescope) was $-34^\circ\,55'\,37''{\cdot}53$. As regards the z phenomenon, the values for Adelaide were found to be in the same sense as those in the Northern hemisphere.

In July we were honoured by a visit from Dr. Kimura, who continued his journey afterwards to the latitude station at La Plata.

During October and November and the early part of December the world longitude signals from Bordeaux, Saigon, Malabar, Tokyo, Honolulu, and Cavite were received daily, and star observations for time determination were made on every clear evening. Valuable assistance in this work was given by Professor Kerr Grant of the Adelaide University in the construction of apparatus for receiving the wireless time-signals, and in linking up the Shortt Free Pendulum Clock at the University with the observatory clock

(Riefler) for the reception of the longitude signals and for the time determinations.

Lectures on astronomy for surveyors were continued at the University throughout the year by the Director.

Magnetic observations were made at Kadina on the site of a copper-bearing deposit, associated with magnetite, and the direction of the lode was mapped out.

A number of photographs of various regions of the sky were obtained with a wide angle camera lens in the search for comets, asteroids, etc. Comet 1932 *n* was followed in the early part of the year, as long as it remained visible in the Southern sky.

Seismograph records were obtained continuously throughout the year with the Milne and Milne-Shaw Seismographs, and the results were sent to the British Seismological Committee, and monthly bulletins also to seismological observatories.

Commonwealth Solar Observatory, Canberra, Australia
(*Officer-in-Charge, Mr. W. B. Rimmer*)

Sun Telescope.—The researches on the intensities and contours of Fraunhofer lines have been continued. Microphotogram traces over the region 4300–6600 A. have been made from a series of plates, each of which has been photometrically standardised. Two methods of standardisation have been employed: (*a*) a slit-width method, (*b*) an absorption-screen method. The whole region of the spectrum has been measured at least twice; generally once by each method. From the traces the percentage absorption in the centre of the line has been obtained for about 2600 Fraunhofer lines. Each value has then been corrected for the influence of the neighbouring lines (if any), and for the finite resolving power of the spectrograph (determined experimentally). Intensity contours have been plotted for 300 selected lines distributed throughout the spectrum, and the equivalent breadths of these lines have been measured. Using these lines as a basis, it has been possible to derive the equivalent breadths of the remaining 2300 lines.

A study of the implications of this experimental data is now in progress and interesting results are being obtained.

Atmospheric Electricity.—Observations of the electrical conductivity of the atmosphere and the air-earth current, together with concentrations of nuclei and small ions, have been continued.

Apparatus has been constructed and methods developed which permit of the continuous and automatic registration of the mean life of small ions, the rate of ionisation of the atmosphere, and the concentration of small ions. Forty complete records have been obtained and further work will be done with a modified apparatus.

In order to measure the distribution of the intensity of highly penetrating radiation, Geiger counter-tubes with photographic registration and thermostatic control have been constructed. A high-pressure ionisation vessel,

with which it is proposed to carry out a long series of measurements of the intensity of the penetrating radiation, is in course of construction.

Radio Research.—Observations of the direction, intensity and duration of sources of "atmospherics" have been continued with the continuous recorder, and, using simultaneous observations on the cathode ray direction-finder, on a number of days their exact positions have been located. Improvements to the recorder have been made, *e.g.* reducing the speed of rotation of the frame aerials from four to two revolutions per hour, and increasing the operating frequency from 10 to about 30 kilocycles per second. This has improved the recording of sources of low activity, and limited the sources to those within or near the Australian continent, thus simplifying the charts and facilitating their meteorological interpretation.

Analysis of the records has given information as to daily and seasonal variations in frequency, intensity and duration of sources of atmospherics for a large part of the Australian continent. This has allowed their interference to broadcast (or other) reception to be predicted for any particular areas, and is of value in developing broadcasting services.

Publications.—Two papers have been prepared, one on the interrelations of atmospheric electric observations obtained over a period of two and a half years, the other on the equilibrium of the ionisation in the lower layers of the atmosphere. These papers are appearing in *Gerlands Beiträge zur Geophysik* (vol. 41, No. 1, 1934). Also a paper, "Measurements of Atmospheric Ozone," is being printed as Memoir No. 3 of the Commonwealth Solar Observatory. Other papers are in preparation.

General.—The programme of work, as outlined in the reports of previous years, has been continued.

Melbourne Observatory

(*J. M. Baldwin, M.A., D.Sc., F.Inst.P., Government Astronomer*)

Work with the 8-inch transit-circle on the list of fundamental stars has been continued, and at the request of Dr. H. Kimura a number of stars used for latitude variation observations have been interpolated in the list. Observations of southern long-period variable stars have been continued during the year, and have been published regularly in *Popular Astronomy* in the American A.V.S.O. lists.

The Astronomer Royal having offered to undertake the measurement of the Eros plates taken at Melbourne, his offer was gratefully accepted, as it was felt that the conditions at Melbourne would cause undue delay in making the measurements. The plates have been forwarded to Greenwich.

Once more, lack of funds and depleted staff have prevented any progress being made in the printing of the fourth and fifth Melbourne *General Catalogues*, of vols. iv and v of the *Astrographic Catalogue*, or of the hourly values of the magnetic elements. Magnetic and seismological work has been carried on as in previous years, and seismological bulletins have been issued quarterly.

During October and November time-signals from Bordeaux and Saigon

were received daily in connection with the International Longitude Determination.

The Dominion Observatory, Wellington, New Zealand
(*For the Year* 1932)

(*Director, Dr. C. E. Adams, Dominion Astronomer and Seismologist*)

The time service has been maintained, and the regular daily signals transmitted. The total number of signals sent from the observatory was 2388. Besides the usual signals transmitted through the Government radio station ZLW, signals have also been transmitted through the broadcasting station 2YA at Wellington. The usual method of recording radio time-signals has been to use the chronograph with the hand key. 1095 signals on 6 call-signs were received, including both mean time and rhythmic signals.

Summer Time.—The Summer Time Act, 1929, provided for the time in New Zealand being half an hour in advance of New Zealand standard time, for the period beginning at 2 a.m., New Zealand standard time, on Sunday 1932 October 9, and ending at 2 a.m., New Zealand standard time, on Sunday 1933 March 19.

Occultations.—By co-operation with the New Plymouth Astronomical Society 16 occultations were observed, and the results have been forwarded to Dr. L. J. Comrie.

Lunar Eclipse.—The partial lunar eclipse of 1932 March 22 was well observed photographically and visually with the 9-inch telescope. Ten photographs were obtained of the eclipsed Moon at the principal focus of the 9-inch photovisual lens, and the times of occultation of two faint stars during the eclipse were observed.

Comet Geddes, 1932 g.—It is a pleasure to record the discovery of an 8th magnitude comet by Mr. M. Geddes, Otekura, South Island, on 1932 June 22, with a 5-inch telescope on loan from the observatory. The discovery was reported to the International Astronomical Union through the Melbourne Observatory, with the result that the Union Observatory in South Africa was able to obtain accurate photographic positions on June 23. It was well observed throughout New Zealand, also by Dr. Baldwin at Melbourne, and by the Cordoba Observatory in South America. From the observations made with the 9-inch telescope at Wellington, an orbit was computed. An orbit and ephemeris were also received from Dr. Bobone at Cordoba.

Seismology.—During the year 1054 earthquakes were recorded on the seismographs. The total number of earthquakes felt in New Zealand was 314, 250 of these being felt in the North Island and 70 in the South Island, while 6 were experienced in both islands. Epicentres of 24 earthquakes, which were of high intensity, or felt over a large area, were determined.

The most important earthquake during the year 1932 was that which occurred in the Gisborne-Wairoa region on September 16, the time at origin being $1^h\ 24^m\ 57^s$ N.Z.M.T. The intensity at Wairoa was slightly greater

than R–F 9 and at Gisborne between R–F 8 and 9. Considerable damage was done to buildings in both towns. The epicentre, as determined from the records of the New Zealand Seismological Stations, was found to be situated a short distance off the coast, to the eastward of Mahia Peninsula.

A Milne seismograph has been established at the Chatham Islands. Strong motion Milne-Jaggar seismographs have been established also at Tuai, Bunnythorpe and Greymouth. Private observers at Dannevirke and Christchurch also supply seismograms of important earthquakes to the observatory.

Mr. Robert Barker's Observatory, Cheshunt, Herts

The programme of work included a study of the Martian surface features, a complete planisphere being obtained. Observations of Saturn showed an eccentric position of the ball within the rings and the variability of Rhea, Dione and Tethys at various positions in their orbits. Many hitherto unrecorded features were observed on the Moon. The seeing conditions were generally good throughout the year.

Telescope.—12·6-inch Calver equatorial.

Mr. A. F. Bennett's Observatory, Leiston, Suffolk

The 6-inch refractor has been employed mainly for solar and planetary observations, and the cameras on photographing various objects and star fields. Five occultations of stars by the Moon were observed and the results reported.

During the year (June–July) the observatory was removed to a new site, not far from the old one, affording a better horizon in all directions. The equatorial has been overhauled and re-erected there. The co-ordinates of the new position are: Lat., N. 52° 11′ 58″·3; Long., E. 1° 34′ 45″·5; Alt., 18 metres.

Rev. T. E. Espin's Observatory, Wolsingham

The survey for new double stars in the zones +35° to +40° has been continued, and the results communicated to the Society.

Mr. Evershed's Observatory, Ewhurst, near Guildford

Spectroheliograms in $H\alpha$ light for the estimation of character figures were obtained on 60 days only. Owing to the low density of the prominences at the present time of minimum sunspot activity, absorption markings are shown on very few of the images.

The H and K lines in 68 prominence spectra have been photographed with calcium and iron arc comparison spectra. These are measured for estimating the rotation velocity and shift towards red of the calcium lines, in continuation of previous work. An improved method of measuring these spectra has been devised.

Numerous high-dispersion spectra have been secured during the year with the liquid prism spectrograph. These include spectra of the centre and limbs of the Sun, with iron arc comparison. The plates should yield good values of the shifts towards red of certain iron triplets at the Sun's centre and limbs, as well as values of the solar rotation given by high- and low-level lines. Spectra were also obtained of sections of the Sun's disc which have revealed numerous small displacements, probably due to horizontal movements in the lower reversing layer. The preliminary results of this last research have been communicated to the Society.

The positive-on-negative method of measuring small displacements of spectrum lines has given very satisfactory results for the solar rotation plates, and it has also been successfully applied in detecting and measuring the very small shifts in some of Dr. Hale's solar spectra on which he based his discovery of the general magnetic field in the Sun.

Mr. F. J. Hargreaves's Observatory, Kingswood, Surrey

Measurements of double stars with the comparison-image micrometer have been continued, and the results in some cases differ from the ephemerides by considerable amounts, although the internal accordances continue to be good.

During the period 1932 December to 1933 June, 1020 central-meridian transits of markings on Jupiter were obtained. A few drawings of Mars were made. The dome was lined internally with heat-insulating board ("celotex") in order to minimise temperature variations and dewing.

A 14½-inch mirror of low-expansion glass is being put in hand to replace the 12¼-inch mirror, which has been found very difficult to use for photography owing to variations of focal length with changes of temperature.

Mr. Newbegin's Observatory, Worthing, Sussex

The large amount of brilliant sunshine during the year has resulted in a record number of observations. The deductions indicate a rapid decline in the Sun's activity and the actual minimum period seems imminent.

The mean daily frequency for prominences from 150 observations was 6·51 and the distribution was fairly uniform, with a very slight excess north of the equator and on the west limb. Some good displays were seen, but the great majority of the prominences were small and insignificant. Metallic activity was recorded in 10 prominences, one of which was at the South Pole. No metallic prominence was seen in the last six months of the year. $H\alpha$ displacements occurred in 22 prominences, 17 of which were to the violet, and nearly all were recorded in the first half of the year.

For sunspots the mean daily frequency was 0·52 from 165 observations. The northern hemisphere had the greatest amount of activity, 86 per cent. of the spots being north. 99 days were without spots.

The most active period was the first three months of the year; then a distinct drop in frequency occurred which, with small fluctuations, continued

to the end of 1933. August was particularly quiet, no spots being seen on any day of observation.

Spectroscopic observations of the sunspots yielded very little and only occasionally was the *C*-line violently disturbed. Further details may be found in the *Journal of the B.A.A.*, 43 and 44.

The spectrohelioscope referred to in the report last year is very nearly completed and it is hoped to erect it in the course of the next few weeks.

Mr. B. M. Peek's Observatory, Solihull, Birmingham

Physical observations of the major planets, particularly of Jupiter, have as usual constituted the main work of the observatory. During the apparition of 1932–33 1407 transits of spots across Jupiter's central meridian were recorded.

Photometric observations of Nova Persei 1901 have been continued.

During 1933 eleven occultations of stars by the Moon were observed, the records of which will be communicated to the Computing Section of the B.A.A. for reduction and publication.

The Rev. T. E. R. Phillips's Observatory, Headley, near Epsom

The 8-inch refractor lent by the Society was used chiefly in the measurement of a number of Struve and Otto Struve double stars, and observations of the spots on Saturn. The 18-inch reflector was generally employed for observations of Jupiter and Mars. Despite much poor seeing, the prevalence of clear nights enabled an unusually large number of transit observations of markings on Jupiter to be secured. It was found that the abnormal circulating drift of objects in the S. Tropical region of the previous apparition persisted.

Dr. Waterfield's 6-inch photographic triplet of 27 inches focal length by Messrs. Cooke, Troughton & Simms was delivered and mounted at the end of 1933 January. It is found to be a lens of the highest quality. An f/3·0 Aldis lens of 8 inches focal length is fixed on the same mounting. Over 40 plates have been obtained with each lens—mostly long exposure photographs of the Milky Way and diffuse nebulæ.

A 3-inch Cooke transit and Cooke sidereal clock were presented by Miss Player of Cheltenham. The former has been substituted for the Matthew transit; the latter and the Lupton clock have recently been installed in the cellar underneath the Rectory and wired up with dials in the observatories. Mr. Will Hay presented one of his chronographs with which both clocks have been connected.

A paper by Dr. Waterfield, giving the result of measures of the relative brightness of the eclipsed and uneclipsed Moon on 1932 September 14, has been communicated to the British Astronomical Association.

The observers took part in an expedition to Canterbury to observe the grazing occultation of Regulus by the Moon on 1933 April 6. In consequence of clouds no results were obtained.

Dr. W. H. Steavenson's Observatory, West Norwood

Observations were made on 163 nights during the year.

The 20-inch Hindle reflector was used chiefly for photometric work on objects between the 12th and 16th magnitudes. Observations under this head include 525 of 23 long-period and irregular variables, 182 of 9 novæ, and a few of the satellites of Uranus.

The comets Dodwell-Forbes, Peltier and Geddes were observed for position on several nights, and the measures were communicated, as soon as made, to the I.A.U. bureau at Copenhagen.

Physical observations were made of Mars from January to April, and of the white spot on Saturn in August and September. A few occultations were also observed during the year. The mirrors of the reflector were re-silvered in March and November.

Mr. Tomkins's Observatory, Dedham, Essex

It is very unfortunate to have to report that photographic and other night work in the observatory has been practically impossible during the year on account of illness. Attention has therefore been given largely to the plates already taken, and a considerable number of these have been thoroughly examined and details recorded.

In the workshop, the shaping of the half-size iron grinding tools had been taken up on 1932 July 6, and having been brought to curve ready for use, it was possible in the year under report to proceed with the construction of the 30-inch mirror, which it is hoped will later on take the place of the 24-inch in the reflecting telescope. The glass disc for the 30-inch mirror has now been ground out to the edge and bevelled, and the curve of the mirror has reached the required depth and been fine ground so far with No. 400 carborundum. This has permitted of measurement with the spherometer, and shows very satisfactory results all over the surface. The fine grinding, polishing and figuring of course remain to be done. Much work still remains, but it is satisfactory to be able to report that the glass disc gives so far good indications of being perfect and should result in a satisfactory mirror. It is hoped to resume observational work shortly.

NOTES ON SOME POINTS CONNECTED WITH THE RECENT PROGRESS OF ASTRONOMY

Minor Planets

Two hundred and sixty-nine planets were discovered or first announced in 1933. The dates of discovery are given approximately by the lettering ; discoveries in January have the first letter A or B, those in February C or D and so on ; I and J are treated as one letter, so that December has X or Y for the first letter.

S. Arend (Uccle) BA, FC, FD, FE, FF, FG, QG, QH, QJ, QK, QL, SC, SE, SF, SL, SF_1, UA, UB, UC, UD, UE, UF, UG, UH, UJ, UK, UM, UN, UO, UP, UQ ; L. Boyer (Algiers) WD, WE ; E. F. Carpenter (Steward Observatory, Tucson) RD ; J. Comas Sola (Barcelona) UY ; L. E. Cunningham (Harvard) TB, UL, UP, UQ ; E. de la Villemarqué, S.J. (Zo-Se), 1932 WM ; E. Delporte (Uccle) BB, FA, FB, FL, GA, QA, QB, QC, QD, QE, QF, QM, QN, QL_1, RA, RB, RC, SA, SB, SK, SM, SN, SO, UR, US, UT, UU, UV, UW, UX, UC_1, UU_1, UV_1, WA, WB, also 1930 SW ; C. Jackson (Johannesburg) FY_1, HJ, LA, LB, MB, MC, MD, OR, PA, QM_1, QO, QR, QS, RE ; M. Mündler (Heidelberg) BL, DD, FV, SJ_1, WM ; K. Nakamura (Kyoto) 1931 LE ; S. Necrassoff (Simeis) 1932 VC, 1932 WJ ; G. Neujmin (Simeis) HA, MA, NA, OQ, QO, QP, QQ, QR, QS, QT, SO, ST, SU, SV, SW, SX, SY, SZ, SA_1, SB_1, SC_1, SD_1, SE_1, SK_1, SL_1, SM_1, UP_1, UQ_1, UR_1, US_1, UT_1, VA, VB, WC, WF, WN, also 1932 YQ ; G. Raynal (Hamburg) 1930 WK ; K. Reinmuth (Heidelberg) BC, BD, BE, BF, BG, BH, BJ, BK, BM, BN, BO, BP, BQ, BR, BS, BT, BU, BW, DB, DC, DE, DF, FH, FJ, FK, FL, FM, FN, FO, FP, FQ, FR, FS, FT, FU, FV, FW, FX, FY, FZ, FA_1, FB_1, FC_1, FD_1, FE_1, FF_1, GB, GC, GD, GE, GF, HB, HC, HD, HE, HF, KA, KB, OA, OB, OC, OD, OE, OF, OG, OH, OJ, OK, OL, OM, ON, OO, OP, OS, QT, QU, QV, QW, QX, QY, QZ, QA_1, QB_1, QC_1, QD_1, QE_1, QF_1, QG_1, QH_1, QJ_1, QK_1, SG_1, SH_1, UD_1, UE_1, UG_1, UH_1, UJ_1, UK_1, UL_1, UM_1, UN_1, UO_1, VC, WG, WH, WJ, WK, WL, also 1929 CH_1, 1932 BO ; F. Rigaux (Uccle) FK, SD, SH, SJ, SP, SQ, SR, SS ; R. Schorr (Bergedorf) DA, FH, FJ ; W. Strobel (Heidelberg) UF_1 ; G. van Biesbroeck (Yerkes) BV, OT, TA, also 1932 WK, 1932 WL ; H. van Gent (Johannesburg) 1930 KG, 1930 QT ; F. L. Whipple (Harvard) DG ; H. E. Wood (Johannesburg) FX_1, HG.

The following identities have been established :—

610 = 1933 SG (610 has been missing since its discovery in 1906) ; 680 = 1932 KH ; 785 = 1904 PG ; 813 = 1907 YS ; 857 = 1906 TX ; 858 = 1908 EN ; 872 = 1913 *p* ; 895 = 1906 UMb ; 919 = 1903 NG = 1928 UE ; 924 = 1906 SL ; 932 = 1909 GT ; 947 = 1906 XC = 1921 JD ; 952 = 1908

CN ; 954 = 1920 HF ; 959 = 1916 AX ; 971 = 1908 EQ ; 972 = 1912 OG ; 999 = Σ10 ; 1010 = 1903 MS ; 1012 = 1907 BG ; 1013 = 1905 RP ; 1021 = 1910 JQ ; 1027 = 1908 BR ; 1031 = 1913 SS ; 1044 = 1929 RP ; 1054 = 1907 XV ; 1055 = 1902 JW ; 1058 = 1906 WN ; 1059 = 1920 GW ; 1085 = 1908 DB ; 1129 = 1914 *b* ; 1146 = 1913 RO ; 1148 = 1924 RZ ; 1165 = 1909 HO ; 1180 = 1908 DE = 1916 *j* ; 1200 = 1913 RC = 1915 *q* ; 1211 = 1920 HL ; 1214 = 1930 QD ; 1223 = 1909 FU = 1930 MN and possibly = 1907 AS ; 1257 = 1928 QA.

The following identities among the unnumbered planets have been announced :—

1901 *b* = 1929 WG ; 1905 RX = 1933 SH ; 1907 AJ = 1933 RA ; 1908 DA = 1931 XB ; 1918 EF = 1932 WC ; 1927 BD = 1933 BM ; 1928 FO = 1929 MA = 1933 BT ; 1928 QD = 1933 QR ; 1929 RG = 1933 QH ; 1930 SH = 1931 VY ; 1931 UF = 1933 BN ; 1931 TV_1 = 1933 BO ; 1932 KF = Σ86.

Also a planet photographed at Simeis on November 21 and again at Uccle in December may be the long missing 603 Timandra.

The following planets have received permanent numbers :—

1927 SD = 1224 ; 1930 HK = 1225 ; 1930 HL = 1226 ; 1931 TD = 1227 ; 1931 TU = 1228 ; 1931 TP_1 = 1229 ; 1931 TX_1 = 1230 ; 1931 TE_2 = 1231 ; 1931 TF_2 = 1232 ; 1931 TG_2 = 1233 ; 1931 UF = 1234 ; 1931 UJ = 1235 ; 1931 VX = 1236 ; 1931 XB = 1237 ; 1932 CA = 1238 ; 1932 CB = 1239 ; 1932 CD = 1240 ; 1932 EB_1 = 1241 ; 1932 HL = 1242 ; 1932 JE = 1243 ; 1932 KE = 1244 ; 1932 KF = 1245 ; 1932 OA = 1246 ; 1932 QA = 1247 ; 1932 RO = 1248 ; 1932 VB = 1249 ; 1933 BD = 1250 ; 1933 BE = 1251 ; 1933 DG = 1252 ; 1931 TV_1 = 1253 ; 1932 JA = 1254 ; 1932 NC = 1255 ; 1932 PD = 1256 ; 1932 PE = 1257 ; 1932 PG = 1258 ; 1933 BT = 1259 ; 1933 BW = 1260 ; 1933 FB = 1261 ; 1933 FE = 1262 ; 1933 FF = 1263 ; 1933 HG = 1264.

The following planets have been named :—

1009 Sirene ; 1011 Laodamia ; 1012 Sarema ; 1014 Semphyra ; 1015 Christa ; 1016 Anitra ; 1020 Arcadia ; 1025 Riema ; 1041 Asta ; 1042 Amazone ; 1043 Beate ; 1044 Teutonia ; 1047 Geisha ; 1049 Gotho ; 1050 Meta ; 1051 Merope ; 1054 Forsytia ; 1056 Azalea ; 1060 Magnolia ; 1061 Pæonia ; 1063 Aquilegia ; 1064 Aethusa ; 1066 Lobelia ; 1067 Lunaria ; 1070 Tunica ; 1072 Malva ; 1076 Viola ; 1077 Campanula ; 1078 Mentha ; 1080 Orchis ; 1081 Reseda ; 1082 Pirola ; 1083 Salvia ; 1085 Amaryllis ; 1087 Arabis ; 1091 Spiræa ; 1092 Lilium ; 1095 Tulipa ; 1097 Vicia ; 1099 Figneria ; 1100 Arnica ; 1101 Clematis ; 1104 Syringia ; 1105 Fragaria ; 1106 Cydonia ; 1108 Demeter ; 1111 Reinmuthia ; 1116 Catriona ; 1118 Hanskya ; 1119 Eubœa ; 1126 Otero ; 1130 Skuld ; 1131 Porzia ; 1132 Hollandia ; 1133 Lugduna ; 1138 Attica ; 1142 Aeotolia ; 1144 Oda ; 1146 Biarmia ; 1147 Stavropolis ; 1150 Achaia ; 1151 Ithaka ; 1156 Kira ; 1157 Arabia ; 1158 Luda ; 1159 Granada ; 1160 Ilyria ; 1161

Thessalia ; 1162 Larissa ; 1163 Saga ; 1165 Imprinetta ; 1166 Sakuntala ; 1174 Marmara ; 1175 Margo ; 1180 Rita ; 1182 Ilona ; 1183 Jutta ; 1184 Gæa ; 1187 Afra ; 1189 Terentia ; 1190 Pelagia ; 1198 Atlantis ; 1200 Imperatrix ; 1201 Strenua ; 1211 Bressole ; 1212 Francette ; 1225 Ariane ; 1226 Golia ; 1235 Schorria ; 1237 Geneviève ; 1239 Queteleta ; 1240 Centenaria ; 1241 Dysona ; 1242 Zambesia ; 1244 Deira ; 1245 Calvinia ; 1252 Celestia ; 1254 Erfordia ; 1261 Legia ; 1262 Sniadeckia ; 1263 Varsavia.

The feature of the year has been the large number of identifications with planets discovered in former years but long unobserved. In regard to this, Dr. Stracke points out (*R.I.C.* 867) that it would be better to devote more time to recovering old planets, and less to accumulating immense numbers of new ones ; the majority of these are insufficiently observed to provide material for orbits ; he made a special appeal for observation of the interesting planet 887 Alinda, which had been missing for many years ; he prepared an accurate ephemeris which led to the recovery of the planet, and it was well observed.

The orbits of two interesting planets are given : 1252 Celestia was discovered by Dr. F. L. Whipple at Harvard ; he and Mr. L. E. Cunningham deduced the elements. 1933 WC was discovered by Dr. G. Neujmin at Simeis, and attracted attention by its rapid southward motion of half a degree daily ; the perihelion distance is 1·64.

Planet	1252	1933 WC
Epoch	1925 Jan. 1·0	1933 Nov. 27·0
M	23° 42′ 25″	15° 26′ 33″
ω	62° 10′ 26″	147° 0′ 13″
Ω	140° 49′ 23″	238° 6′ 29″
i	33° 58′ 52″	23° 53′ 5″
ϕ	11° 43′ 19″	18° 46′ 58″
n	802″·590	944″·506
log a	0·43035	0·38320
Equinox	1925·0	1933·0
Reference	*Klein. Plan.* 1934	*R.I.C.* 902

Celestia has the highest inclination of the family, with three exceptions : 944 Hidalgo, i 43·062° ; 2 Pallas, i 34·736° ; 531 Zerlina, i 34·548°.

Considerable interest was excited by a planet discovered at Johannesburg in May during the search for Finlay's comet ; it was unexpectedly bright considering its distance from opposition, but it was eventually found to be identical with 192 Nausicaa.

K. Boda has published perturbations of 287 planets from 1932 to 1940 in *A.N.*, **249**, 17. There are also studies of the orbits of particular planets in *A.N.*, **250** : p. 5, planet 872 Holda, by P. Vocca ; p. 46, planet 1036 Ganymede, by I. Putilin ; p. 71, planet 887 Alinda, by G. Stracke ; p. 157, planet 784 Pickeringia, by Mrs. M. W. Makemson ; p. 281, planet 588 Achilles, by S. Sigurdsson ; p. 293, planet 928 Hildrun, by I. Putilin.

Planet 944 Hidalgo, which has the longest period (13·67 years) of any minor planet, is due at perihelion about 1934 November 9 ; it was last seen in 1922 ; its distance from the Earth will be about 1·4 next November ; it will be in high north declination. A. C. D. C.

Comets

The comet 1925 II, Schwassmann-Wachmann (1), has now been observed every year since its discovery in 1927; it passed its aphelion in 1933 July; there is thus every reason to expect that it will remain continually under observation. The mysterious outbursts of light to which it is liable have continued in 1933; the first occurred early in January, when the light increased from magnitude 17 to 12; on January 24 Professor G. van Biesbroeck at Yerkes found the diameter of the coma to be 40″, with strong central condensation; it then faded, and had fallen to magnitude 15 on February 18, and to magnitude 16 on March 15. Another outburst followed; photographs taken at Bergedorf on April 22 showed the comet as a bright circular nebula of magnitude 12; Professor van Biesbroeck found the magnitude to be 12·5 on May 23, the coma being 20″ in diameter, with central condensation. The comet was distant more than seven units from the Sun at the time of these outbursts. Since the comet was near aphelion in 1902, it is probable that a similar outburst was in progress when images were formed on plates exposed by Dr. Reinmuth at Königstuhl in that year, though they were not detected till much later. Mr. L. E. Cunningham, who made the identification of these images with comet 1925 II, has undertaken the deduction of definitive elements for this comet. There is abundant material for this purpose, since the comet has been observed in seven consecutive years, in addition to the 1902 positions.

Comets Kopff, Brooks and Newman, discovered in 1932, were followed at Yerkes till February 1933, and Faye, Borrelly and Dodwell-Forbes still longer; a photograph of comet Dodwell-Forbes on January 20 showed a large round coma, and a fan-shaped tail 1° in length (*P.A.*, February). Comet Geddes was followed through the year, being outside Jupiter's orbit at the end of it. At Posen on March 18 it was described as a circular nebulosity $2\frac{1}{2}'$ in diameter, magnitude 9·6, with nucleus (*B.Z.* No. 5). On April 13 and 17 Fr. Kaiser at Wiesbaden saw a tail half a degree long (*R.I. Circ.* 759). *Harv. Circ.* 268 announced that Dr. Whipple found an image on a Bloemfontein plate taken nearly a year before the discovery, which he measured as follows:—

1931 August 14·10428 U.T., R.A. (1931·0) $1^h\ 59^m\ 23^s{\cdot}07$, S. Decl. 44° 19′ 45″·8, mag. 13·0.

This position will be of value in determining the orbit, which is probably hyperbolic. Dr. Whipple also found two prediscovery images of comet 1932 V on Bloemfontein plates. These extend the arc of observation by 24 days (*Harv. Circ.* 270).

U.T.	R.A. 1932·0	Decl.
	h m s	° ′ ″
1932 July 13·14468	2 24 16·94	S. 0 24 48·1
July 23·15374	2 36 10·02	N. 2 8 10·2

Comet 1933 *a*, of the eighth magnitude, was discovered by Mr. L. C. Peltier, of Delphos, Ohio, on February 15. It is the fourth comet that he

has discovered in the course of his work on variable stars. It was in North Declination 62°, and thus well placed for observation. It proved to have passed perihelion on February 6, its inclination being 86° 40′. Several observers gave the diameter of the coma as 3′, with slight central condensation. The magnitude fell to 12 at the end of March. No later observations have come to hand.

Comet 1933 *b* is the periodic comet Pons-Winnecke; it was detected by Dr. A. Wachmann at Bergedorf on March 24, the magnitude being 14. Professor G. van Biesbroeck then found images on plates that he had exposed on February 18; but being near the edge of the plates they could not be measured very exactly. Perihelion passage was on May 18, the perihelion distance being 1·10169, an increase of 0·06247 since 1927. There have been close approaches to Jupiter at alternate aphelion passages for some time, which have caused a large increase in q; it was 0·769 in 1858.

The least distance from the Earth, about 0·54, also occurred in May; the brightness does not appear to have risen above magnitude 9. After perihelion the comet was well observed at the Union Observatory, Johannesburg, till September 22. Dr. Adamopoulos also obtained a series of observations at Athens in August (*U.A.I. Circ.* 450), though the south declination was 33°. The physical appearance was noted at Johannesburg in June as

Ref. No.	Year and Number of Comet	Name	*T* G.M.T. till 1925·0 U.T. from 1925·0	ω	Ω	i
				° ′ ″	° ′ ″	° ′ ″
13B	868	...	Mar. 4·	277	305	65
27	1366	...	Oct. 18·04	164 48	218 30	149 48
477	1907 IV	Daniel	Sept. 3·96153	294 25 56	143 2 54	8 58 5
524	1917 I	Mellish	Apr. 10·67514	121 17 56	87 31 33	32 41 0
526	1917 III	Wolf	June 16·56938	120 37 21	183 17 44	25 40 11
597	1931 IV	Ryves	Aug. 25·90803	168 14 8	101 28 40	169 18 0
598	1931 V	Carrasco	Nov. 30·6729	110 18 45	17 50 4	58 4 53
608	1932 X	Dodwell-Forbes	Dec. 30·52167	327 20 4	77 40 22	24 30 4
,,	,,	,, ,,	Dec. 30·51633	327 19 41	77 38 55	24 30 33
609	1933 I	Peltier	Feb. 6·689	135 58 41	311 31 51	86 40 5
610	1933 II	Pons-Winnecke	May 18·8138	169 16 10	96 39 32	20 8 34
611	1933 III	Giacobini-Zinner	July 15·154	171 48 29	195 58 12	30 41 52
612	1933 IV	Whipple	July 19·54056	186 16 0	189 4 15	10 22 29
...	1933	Carrasco	July 22·26	193 16	110 42	173 2
...	1934	Wolf (1)	Feb. 27·77182	160 48 55	204 11 7	27 15 49

Notes.—The first two orbits are based on Chinese and Japanese observations. Dr. Hind identified both with Tempel's Comet 1866 I. This is negatived for the first, and confirmed for the second. The orbits for 610, 611 are not final. The

"large, round, diffuse, with no stellar nucleus; magnitude 9·5." The orbit given below is based on some of the 1933 observations, but is not definitive, the period being probably too long.

Comet 1933 *c* is the periodic comet Giacobini-Zinner. It was detected by Professor R. Schorr at Bergedorf on April 23, the magnitude being 15. It was within ½° of the predicted position given by Mr. F. R. Cripps in *B.A.A. Handbook* for 1933. The orbit of this comet makes a very near approach to that of the Earth, and a rich shower of meteors belonging to its system was observed on October 9·8 U.T., the node of the meteors agreeing exactly with that of the comet. The least distance of the comet from the Earth was 1·22 units (114 million miles) early in July. Very few observations of this comet have been published; the latest are those by P. Finsler at Zürich on July 25 and 26; the visual magnitude was then 12 (*B.Z.* 33). The approximate orbit given below is based on the April and July positions.

Comet 1933 *d* was announced by Dr. R. Carrasco, Director of the Madrid Observatory, from plates exposed on July 15 and 17; the images on July 15 were well defined, and decidedly cometary in character, so that a telegram was sent without waiting for further confirmation; no plate could be taken on the 16th; on the 17th a faint diffused image was photographed, but the position did not agree very well with that expected from

Ref. No.	log *q*	Period in Years or Eccentricity *e* in Hyperbolic Orbits	Equinox	Computer	Reference
13B	9·794	...	868·0	S. Kanda	*Mem.Astr.Soc.Japan.*
27	9·99518	34·07	1366·0	,,	,, ,,
477	9·709417	8740	1910·0	U. Baehr	*A.N.*, **249**, 241.
524	9·279179	145·34	1917·0	S. Asklöf	*Ark.f. Mat.*, **23**, A.
526	0·226974	193100	1917·0	J. C. Du Pui	*Utrecht Publn.*
597	8·869818	1·002065 *e*	1931·0	M. Davidson	*B.A.A.J.*, **44**, 73.
598	0·367516	1·002673 *e*	1932·0	P. Herget	*A.J.*, **43**, 38.
608	0·053355	257·5	1933·0	H. Hirose	*U.A.I. Circ.*, 429.
,,	0·053470	279·8	1933·0	A. D. Maxwell	*P.A.*, 1933 March.
609	0·00026	...	1933·0	J. P. Möller	*U.A.I. Circ.*, 428.
610	0·042225	6·1557	1933·0	A. C. D. Crommelin	*B.A.A.J.*, **44**, 39.
611	9·999822	6·60288	1933·0	,,	MS.
612	0·395992	7·77320	1933·0	M. Davidson	MS.
...	0·0060	...	1933·0	A. C. D. Crommelin	MS.
...	0·389206	8·32896	1934·0	M. Kamienski, M. Bielicki	*U.A.I. Circ.*, 465.

period given for 610 is probably too long. The orbit of Carrasco (1933 July) is conjectural.

the previous positions. No further plates could be taken till the 22nd, which revealed nothing cometary. At the request of the writer, Dr. Carrasco kindly remeasured the three positions as follows :—

	U.T.	R.A. 1933·0	S. Decl.
	d h m s	h m s	° ′ ″
1933 July	15 21 12 30	13 10 26·1	12 38 16
	15 21 27 30	13 10 25·0	12 37 41
	17 22 0 0	13 3 46·6	11 38 29

A tentative orbit deduced from these positions is given in the table; there is a discordance of many seconds of arc in the middle place, which cannot be removed with a parabolic assumption. Improvement in R.A. brings deterioration in Decl., and *vice versa*. The orbit implies a very near approach to the Earth on July 13, so that earlier positions would be very distant from those given. The rapid recession from the Earth would explain the fading. Unless other images should be found the comet will not be given a permanent number.

The orbit gives the following prediscovery positions :—

	R.A.	Decl.	Δ
	h m s	° ′	
1933 July 12·0	0 5 8	N. 2 47	0·040
13·0	18 15 24	S. 32 37	0·010
14·0	13 40 24	S. 16 38	0·044

The values of Δ for the first and last observations are 0·1200 and 0·2025.

Comet 1933 *e* is the periodic comet Wolf (1). Professor M. Kamienski, who has studied the motion of the comet in most minute detail from 1875 (nine years before discovery) to the present time, prepared an accurate ephemeris for this return; perihelion passage does not occur till the end of 1934 February, but the comet will then be nearly behind the Sun, so it was necessary to search much earlier. The comet was found by Dr. Jeffers at the Lick Observatory on July 25. The ephemeris began on August 4, but he extrapolated earlier positions. *Harvard Circ.* 273 gives five photographic positions taken with the Crossley reflector between July 25 and 29, giving exposures up to 2 hours; the comet was not quite stellar on the plates; its magnitude was carefully determined in September, by comparison with the Polar Sequence, and was 18·4; it is probably the faintest comet ever observed. The Lick Observatory observations are the only ones reported. W. P. Henderson and J. D. McNeile had also given a search ephemeris in the *B.A.A. Handbook* for 1933; their value of T was February 28·626, which is about 0·85 days too late.

Comet 1933 *f* was found photographically by Dr. F. L. Whipple on a plate exposed in the 16-inch Metcalf telescope at Oak Ridge, Harvard, on October 15; the magnitude was 13. Numerous positions were soon obtained, and by October 23 the conclusion was reached that the comet was one of short period; this was first given as 8·2 years, later as 7·49 years. Perihelion was passed early in August, and the distances from Sun and Earth were increasing, but observations up to December 14 are already to hand, and the comet is likely to be followed for some time longer. The

orbit of Whipple and Cunningham indicates an approach to Jupiter in 1922 within 0·3 unit, so that the orbit must then have undergone large changes.

Finlay's comet was not found in spite of careful search ; the conditions were not very favourable, the distance from the Earth being large. There was also some uncertainty caused by the discordance of nearly a month between the Japanese and British estimates of the date of perihelion. When the discordance was noticed the British computers made a second independent computation for the last two revolutions, including the perturbations of both Jupiter and Saturn. The result agreed closely with their earlier one ; in fact, it was slightly further from the Japanese date than before (*B.A.A.J.*, **43**, 156).

Dr. S. Vsessviatsky is continuing the special study of the brightness of comets that was begun by Dr. Holetschek. He published a general catalogue in the *Russian Astronomical Journal* (**10**, 3, 1933). He assumes that the magnitude of a comet varies according to the law

$$(m - y \log r) - 5 \log \Delta.$$

The third term expresses the fact that the light varies as the inverse square of the distance from the Earth. This is obviously the case provided that there is no phase effect ; examination has shown that such an effect is negligible. The quantity y is found to be about 10 as an average value ; this implies that the light varies as the inverse fourth power of the distance from the Sun. Many others have adopted this law or an approximation to it. It would be strictly true if the physical action of the Sun on the comet varied, like the illumination, according to the inverse square law. The value of y is, however, investigated for all comets for which there is sufficient material. It is noted that y was large in the years 1905 to 1907, which included a sunspot maximum. However, the 1917 maximum does not show the effect.

The conclusion is drawn in the catalogue that there is a general diminution of light in comets in the course of time. Thus Encke's comet is growing fainter by a magnitude per century, but many short-period comets show a greater change.

There are 442 comets in the catalogue, which begins with the apparition of Halley's comet in 1066 and ends in 1932. The absolute magnitude of Halley in 1066 is given as 2 to 3, and in 1910 as 4·0 to 5·8. Sarabat's comet of 1729 is given the value −3, making it easily the greatest absolute magnitude in the catalogue. The perihelion distance being 4 units, it has long been recognised that it must have been a very remarkable comet. The great comet of 1811 and Tycho Brahe's comet of 1577 come next to it, with the figures 0·0 and −1·8. The faintest is Tempel-Swift in 1908 with 15·1. A. C. D. C.

Solar Activity

Sunspots.—Excepting the occurrence of one large group of sunspots, the year 1933, especially during the latter six months, showed the characteristics of minimum epoch of the eleven-year solar cycle, namely, (*a*) infrequent and small, short-lived groups, (*b*) a high percentage of days without spots or faculæ, (*c*) the appearance of high-latitude spots of the new cycle. It may be noted, however, that the mean daily area of spots for the year (90 millionths of the Sun's hemisphere) is greater than is usually associated with the lowest point of the eleven-year cycle, and the mean latitude (about 10°) is likewise further from the equator by 2° or 3°. A continuation of minimum conditions may be expected for several months.

The large group of sunspots seen from February 1 to 13 was an extensive stream, visible to the naked eye about the time of its central meridian passage on February 7·3. The mean daily area of the group was 1100 millionths and its latitude +13°.

The following spots, designated by their times of central meridian passage and their latitudes, were observed spectroscopically to be active on several occasions :—

(1) Jan. 10·1 + 9°	(5) Mar. 28·1 + 5°
(2) Feb. 7·3 +13°	(6) May 18·1 +11°
(3) Mar. 6·2 +15°	(7) Sept. 5·4 −10°
(4) Mar. 24·0 +10°	(8) Sept. 22·8 +14°.

Small bright eruptions observed in *Hα* light were associated with spots Nos. 1, 2, 4 and 8. Several large inward radial velocities up to 90 km./sec., belonging to dark hydrogen markings, were observed near spot No. 2. Radial velocities of the order of 35 to 45 km./sec. were observed near the other spots tabulated. Activity was also observed in two additional spots during the first few hours of their initial development—an active period generally in the life-history of sunspots.

A small group seen on October 10 in latitude +26° and another on October 28–30 in latitude −32° were observed at Mount Wilson to have magnetic polarities opposite to those characteristic of the waning cycle (*The Observatory*, **57**, 34, 1934). There is little doubt that these spots are the forerunners of the new cycle, which it may be safely assumed will show a reversal of the scheme of polarities, as was observed at the sunspot minima of 1913 and 1923.

In spite of decreasing solar activity, terrestrial magnetic disturbance continued relatively high, but the ten small magnetic storms (ranges in $D \geq 30'$, or in H or $V \geq 150\gamma$) recorded at Greenwich (Abinger) during 1933 showed a marked lack of association with sunspots. H. W. N.

Prominences, 1933.—The progressive decline in prominence activity reported for the past few years has at last been arrested. For the year 1933 there is a slight increase over 1932 in calcium prominence areas and a slight

decrease in calcium prominence numbers, but for hydrogen prominence areas and dark markings there is a large increase of activity. It is doubtful whether this increase of activity can be definitely attributed to the new sun-spot cycle—firstly, because in the second half of the year there is no considerable increase over the first half, and secondly, because there is less activity in the southern hemisphere than in the northern, whereas the only high latitude spot group which has appeared in the new cycle was in the southern hemisphere. Moreover, it is unusual for the growth of the prominence cycle to precede the spot cycle.

The mean daily areas and numbers of calcium prominences as derived from Kodaikanal spectroheliograms are as follows :—

Areas

	North	South	Total
1933 January to June ...	1·28	0·89	2·17 sq. mins.
July to December ...	1·47	0·99	2·46 ,,

Numbers

	North	South	Total
1933 January to June ...	5·07	4·50	9·57
July to December ...	4·65	4·13	8·78

Calcium prominence areas show an increase of 5 per cent. over those for 1932, calcium prominence numbers a decrease of 7 per cent., whilst hydrogen prominence areas show an increase of 35 per cent. and hydrogen dark markings an increase of 58 per cent.

The preponderance of activity in the northern hemisphere shown in the previous year is still maintained. The greatest activity is confined to latitudes between 20° and 50°.

Three metallic prominences were observed during the year, as against 2 in the previous year. Of the 3, 2 were observed in the northern hemisphere and 1 in the southern, all being at about 9° of latitude from the equator. Displacements of the hydrogen line in the chromosphere and prominences observed during the year numbered 86, as against 105 in the previous year. Of the displacements 48 were towards the red, 36 towards the violet and 2 both ways simultaneously.

There has been a considerable decrease in the case of bright reversals and displacements of the $H\alpha$ line observed on the disc in the neighbourhood of spots, which is due to the absence of spots on a large number of days during the year. Bright reversals of the $H\alpha$ line on the disc numbered 78, as against 133 in the previous year. Only 3 displacements of the $H\alpha$ line on the disc were noticed during the year, as against 9 in the previous year; 2 of these were towards red and 1 towards violet. D_3 was observed as a dark line on 68 occasions, as against 123 during the previous year.

The mean daily areas of prominences projected on the disc as absorption markings in hydrogen light were 2118 millionths of the Sun's visible hemisphere. Their latitude distribution is similar to that of the prominences,

except that in the second half of the year the activity in the northern hemisphere is mostly confined to the belt 40°–50°, which is not the case for the prominences at the limb.

The mean daily areas of *Hα* prominences in square minutes of arc are as follows :—

	North	South	Total
1933 January to June	0·64	0·45	1·09 sq. mins.
July to December	0·70	0·41	1·11 „

The distribution in latitude is generally similar to that of calcium prominences. T. R.

Solar Research

Corona.—The discovery by Adams and Joy (*P.A.S.P.*, **45**, 301) of the coronal lines λλ 3987, 4086, 4231, 5303 and 6374 in the spectrum of RS Ophiuchi (Nova Ophiuchi No. 3) is an event of significance in the study of coronal radiation. This star is one of the few which shows repeated nova-like outbursts, the last previous maximum occurring in 1898. From 1933 August 18 (*P.A.S.P.*, **45**, 249), about six days after maximum, the star showed nebular lines on a typical Wolf-Rayet background with the "auroral" transition (*Proc. Nat. Acad.*, **19**, 581) line λ 4363 exceptionally strong—an indication of relatively high density ; the nebular lines apparently reached their maximum intensity about September 2. By September 8 there was some evidence of the presence of the coronal line λ 6374, and on October 2, when the nebular lines had become faint, the presence of the five coronal lines was definitely established. An interesting feature of the spectrum at this time was the marked similarity of structure of λλ 5303 and 6374 on the one hand, and of λ 4686, the ionized helium line, on the other. Further details of this remarkable discovery, which promises to throw much light both on the origin of the coronal lines and the physical nature of the corona, will be awaited with interest.

From spectra taken at Sumatra in 1929 Grotrian (*Z.f.Ap.*, **7**, 26) finds photometrically the intensities of twelve coronal lines, and gives the intensity ratio of λλ 6374 : 5303 : 3388 as 1 : 12 : 2. The ratio of intensity of line to continuous spectrum is independent of radial distance from the limb. He confirms Lyot's observation (without an eclipse) that the width of the coronal lines is of the order of 1 A. Attention should also be drawn to a valuable repetition of Lyot's work at Mt. Wilson (*P.A.S.P.*, **45**, 187).

Moore (*P.A.S.P.*, **45**, 147) from a spectrum taken at the 1932 eclipse confirms his earlier result of an outward motion in the corona of 20 km. per second. It is partly on the basis of this earlier observation that Rosseland (*Univ. Obs. Oslo, Pub. No.* 5) puts forward an interesting suggestion of the support of corona and chromosphere by the emission of high speed electrons. One probable consequence of this hypothesis is that the continuous spectrum of the corona originates in scattering by free electrons ; if this is the case, Rosseland points out that, for any probable temperature of the corona, the thermal agitation of the free electrons will give Fraunhofer lines with a half

width of 7 to 10 A. This is a suggestion meriting a careful observational test at the next eclipse, but in the meantime it is worth noting that Moore, who made some of his measures on a Hartmann spectrocomparator, makes no comment on any abnormality of width in the coronal lines.

Chromosphere.—Mitchell and E. T. R. Williams (*Ap. J.*, **77**, 1) give a new method of determining the density distribution in the chromosphere from line heights determined from fixed plate spectra. The tip of the chromospheric line is determined by a certain threshold intensity which is constant for all lines within a small wave-length interval, *i.e.* the number of transitions per second giving the tip of the line is the same for all lines in such a region. For the lines of a multiplet, however, transition probability ratios are theoretically known, and hence, if self-absorption is negligible, the ratio of number of atoms in the line of sight at various heights can be found from the lines of a multiplet. These observed ratios, compared with those predicted by various models with different radial density distributions, enable the authors to find density distributions for various elements. The two most striking results of this work are that, with the exception of helium, all elements show very closely the same density gradient, and secondly, that the density decreases exponentially with the height rather more slowly than it would in an isothermal atmosphere of hydrogen at a temperature of 5000°. The method employed is both ingenious and direct, and the results obtained, though similar to Menzel's, seem more worthy of confidence. The difficulty with the method arises in the question of self reversal, since the theoretically strong lines of the multiplet must have, on account of the direct proportionality between the Einstein coefficients A_{21} and B_{12}, larger atomic absorption coefficients than the faint lines. A complete solution of the problem of radial density distribution from observation demands a knowledge of the mode of formation of lines, whether by excitation or recombination, and the two closely related circumstances of the emissivity as a function of radial height, and the scattering coefficient along the line of sight. Clearly for some time we can only expect partial solutions of the problem, and of such solutions that of Mitchell and Williams is an exceedingly helpful one.

Perepelkin (*Z.f.Ap.*, **6**, 245) statistically examines the consequences of the *assumption* that the chromosphere is made up of small filaments, or spikes of uniform brightness, with heights distributed exponentially; the constants of the exponential distribution he finds from the Simferopol and Arcetri measures of chromospheric height. This assumption enables him to account for the jagged edge of the chromosphere, the observed intensity distribution, the presence of hydrogen flocculi (produced by absorption in the small filaments), and from radial velocity measures the turbulent velocity of 15 km. per second required by Unsöld to account for the contour of the chromospheric lines. A detailed mathematical treatment of why the chromosphere might be expected to have a filamentous structure is given in an interesting and important paper by Chandrasekhar (*M.N.*, **94**, 14). He examines the motions of atoms over a non-uniformly radiating surface, the mean flux from which corresponds to full support by radiation pressure. Having specified the field of force, and confining himself for mathematical simplicity to a one

dimensional variation of the flux, he finds from the equations of motion solutions for which the velocity components are periodic functions of position on the surface. The trajectories of the atoms are also periodic with a wave-like shape (hence the jagged edge of the chromosphere) up to a definite height; beyond this height the motion is aperiodic and the chromosphere is bounded. Introducing the equation of continuity the density distribution is found and agrees closely with observation. Further, introducing probable numerical values for the size of the flocculi, which produce the non-uniformly radiating surface, and their intensity ratios, Chandrasekhar finds velocities of the order required by Unsöld. In short, the theory yields without forcing many of the phenomena actually observed in the chromosphere, and shows promise of applicability to the origin of the prominences. It should be emphasized, however, that the analysis as it stands is applicable only to atoms capable of full support by the mean flux, that is to ionized calcium atoms.

Absorption Lines.—Two Princeton publications by C. E. Moore—*A Multiplet Table of Astrophysical Interest* and *Atomic Lines in the Sunspot Spectrum*—represent valuable contributions to our knowledge of line identifications. The first of these is not only a new and much extended edition of Russell's well-known Table of Ultimate Lines, but is also in a sense a classification according to element and multiplet of the lines appearing in the solar spectrum. The second is a list of atomic lines, selected on the basis of Zeeman effect, which appear in the sunspot spectrum; the list contains 460 new lines, largely discovered by Miss Moore, and for these and the previously known lines are given wave-lengths, Rowland intensity estimates, identifications and excitation potentials. Supplementary to these lists are identifications in the solar spectrum of sulphur by Meissner (*Z.f.Ap.*, **6**, 330), and of ionized sulphur by Bartelt and Eckstein (*Z.f.Ap.*, **7**, 272).

From the Solar Physics Observatory, Cambridge, come two valuable discussions of line contours. In the first of these (*Annals S.P.O.*, **3**, Part 3) Woolley, after restating Eddington's theory of absorption line formation, describes a simple "raster" method of photometrically calibrating plates, and gives central intensities and equivalent breadths for nearly 500 lines in the region $\lambda\lambda$ 4040–4390, as determined from prismatic spectra made by Evershed at Ewhurst. After examining the error due to finite resolving power, he corrects his equivalent breadths for Doppler effect, and from his data tests the validity of the relation, $2 \log W'$ (Doppler corrected equivalent breadth) $= r \log I$ (theoretical intensity). Of the eight multiplets examined only one gives the theoretical relation ($r = 1$), six give the Minnaert-Woolley effect ($r < 1$, theoretically weak lines appear too strong), and two show the reverse effect. By classifying the multiplet lines as diagonal and satellite members, Woolley is able to show that the satellite lines appear too strong relative to the diagonal lines, and that among the diagonal lines the faint lines appear too faint. In the second paper Thackeray (*M.N.*, **94**, 99) discusses measures he has made of equivalent breadths in an iron multiplet in the green, and shows that r is a function of stellar temperature; this result is confirmed for disc and spot in the Sun by the Russell-Adams calibration of Rowland estimates. Thackeray then points out that, if r varies with temperature, a

correction must be made for such variation in making a Russell-Adams calibration; further, if the correction is made he shows that the Maxwell-Boltzmann relation is satisfied, and that it is no longer necessary to postulate departures from thermodynamical equilibrium. Reference should also be made to a paper by Woolley (*M.N.*, **93**, 691), in which from the line contours of neutral and ionized calcium on the one hand, and Chandrasekhar's formula for the continuous absorption coefficient on the other, the electron pressure is found at a given optical depth, and the corresponding ionization temperature calculated.

Pannekoek in an interesting paper (*B.A.N.*, **7**, 151) discusses suggestions by Woolley and Unsöld to account for the observed central intensities. He concludes that the one suggestion is not valid and that the other does not yield sufficient central intensities. The same problem is also discussed by Evershed and Thackeray (*Observatory*, **66**, 228, 275). There appears to be a definite contradiction between theory and observation which is made not the less troublesome by the fact that Childs (*Ap. J.*, **77**, 212) and von Klüber (*Z.f.Ap.*, **6**, 161) find the predicted theoretical behaviour for the atmospheric oxygen lines. The most likely explanation of the anomaly seems to be that of Evershed, who suggests bodily displacements of the contour at various levels due to disturbed regions on the solar surface.

Line Displacements.—In a significant paper Evershed (*M.N.*, **94**, 96) discusses the detection and measurement of small line displacements in the Sun by his well-known positive on negative method of measurement. He finds irregular displacements between 0·002 A and 0·005 A, between the limb and centre of the Sun, which, if attributed to Doppler effect, correspond to irregular tangential currents of the order of 0·36 km. per second. Such currents have often been postulated to account for variations in the spectroscopic determination of solar rotation, but this is the first time that objective evidence of their existence has been furnished.

Sunspots.—Richardson (*Ap. J.*, **78**, 359) studies the intensity ratio of spot to disc, as a function of position, by means of 17 plates selected from the large Mt. Wilson collection of direct photographs. He sets up a calibration by means of Abbot's determination of darkening towards the limb, and checks the accuracy of such a calibration by an independent standardization. Within the limits of observational error he finds no variation across the disc, and points out that this is in accordance with the view of Minnaert and Wanders that at least the upper layers of the spot are in radiative equilibrium. The same writer (*Ap. J.*, **77**, 195) uses the hydrocarbon bands to find, from the theory of dissociative equilibrium, the pressure in the spot to be 0·5 that on the disc. Other interesting features of sunspot observation are the conclusions of Nicholson (*P.A.S.P.*, **45**, 51) from studies of 1000 spots that the magnetic field increases with the area of the spot, and the conclusion of Richardson (*Ap. J.*, **78**, 359) that the temperature of the penumbra decreases with increase of spot area. Both writers indicate the need for caution in interpreting these results, on account of the close relation between scattered light and spot size. Cowling (*M.N.*, **94**, 39) examines, only to dismiss, a suggestion of Larmor for the self maintenance and radial limitation of the

magnetic field in sunspots. He suggests, however, that the currents induced by the motion of the gas in the vicinity of the spot will produce a large disturbance in any external field, and assuming a rapid increase of the general magnetic field of the Sun with depth he is able quantitatively to account for some of the observed features of spots. In this connection it should be emphasized, as Evershed (*M.N.*, **94**, 96) has pointed out, that the general magnetic field of the Sun is just within the limits of detectability with our present resources ; the question of whether the field varies with optical depth must be regarded as yet unanswered by observation. H. H. P.

Stellar Spectroscopy

Bright-Line Stars.—A valuable list of bright-line stars of classes O, B and A has been compiled by Merrill and Burwell (*Ap. J.*, **78**, 87). Their catalogue gives particulars of 410 stars and contains much hitherto unpublished data. It is followed by a useful bibliography of 365 references to observational material, and a brief statistical survey is added showing the distribution of bright-line stars in spectral type, magnitude and position. Twelve distinct areas are noted as specially rich in Be stars, the most striking being the region of the double cluster in Perseus.

A possible mechanism of the characteristic variations of Be spectra has been suggested by McLaughlin (*Proc. N.A.Sc.*, **19**, 44). His theory postulates an extensive nebular, pulsating and rapidly rotating atmosphere, with a central star rotating even more rapidly and undergoing temperature variations. The spectrum variations are then interpreted as pure Doppler effects. A somewhat similar atmosphere has been assumed by Mohler (*Pub. Obs. Univ. Mich.*, **5**, No. 5) in an attempt to determine temperatures of Be stars by applying Zanstra's theory of planetary nebulæ, using the intensities of the bright Balmer lines as compared with the neighbouring continuous spectrum. The method yields promising results which are regarded as lower limits to the temperatures, since any deviations from the assumptions would cause a decrease in the Balmer emission.

The spectra of 4 stars with bright helium lines have been described by Merrill (*Ap. J.*, **77**, 44). Three of these are light variables resembling Z Andromedæ and exhibit the anomalous co-existence of bright lines of *HeI* and *II*, *HI*, nebular lines, *NIII* and *FeII* with dark *TiO* bands. It is suggested that this combination of high excitation lines and *TiO* bands may result systematically under certain stellar conditions, one essential of which must be very low pressure. Merrill (*Ap. J.*, **77**, 51) has also discovered the presence of bright sodium lines, D1 and D2, in the spectrum of the A0 star H.D. 190073.

The spectrum of γ Cassiopeiæ has been shown by Lockyer (*M.N.*, **93**, 362 and 619) to be variable. The two components of each of the hydrogen emission lines $H\gamma$ to $H\zeta$ vary in relative intensity, as shown by eye estimates and checked by wedge measures in the case of $H\gamma$. His observations up to the present suggest a period of approximately four years.

Very few known bright-line stars are of type B9 (only 9 out of 410 in the Merrill-Burwell catalogue mentioned above). The discovery of 2 B9e stars by Shajn (*Pulk. Obs. Circ.*, 6, 18) is therefore of interest. The stars H.D. 196712 and H.D. 164447 both have single emission lines of $H\beta$ superposed on a wide absorption, and it is probable that the structure of $H\beta$ is variable in both stars.

Interstellar Matter.—A valuable contribution to the study of interstellar calcium has been made by Plaskett and Pearce (*Pub. D.A.O.*, 5, No. 3). Previous investigations have been hampered by the insufficiency and lack of homogeneity of the observational material, difficulties which the authors have attempted to overcome by utilising the considerable amount of data available at the Victoria Observatory relating to the intensities and displacements of interstellar calcium lines. Measurements of such intensities and displacements are given for 314 stars of types O and B, mostly based on the Victoria observations but including also the most reliable observations from other sources. The discussion of the results confirms earlier work on the subject and strongly supports Eddington's theory of diffuse cosmic matter. The relation between distance and the intensity of interstellar lines is fully demonstrated, and appears to be exactly linear—a fact which is strong evidence of the uniform distribution of diffuse matter required by Eddington's theory. A more direct demonstration of this uniformity of distribution is given by the result of grouping the stars into nine groups according to distance, and solving each group for the galactic rotation of the stars and of diffuse matter. The mean distance of each group was found to be exactly twice that of the centre of gravity of the intervening diffuse matter. Brief mention is made of the one remaining difficulty in accepting Eddington's theory, namely, the failure to find interstellar lines in types later than B5. Reasons are suggested why such failure should be expected in the majority of stars, and the case of H.D. 698 (mentioned in these Council Notes last year) is cited as definitely removing this difficulty. The relative intensities of sodium and calcium lines also present a slight (though not insuperable) difficulty. It was expected that the sodium lines would be relatively extremely weak, whereas eye estimates show that they are of the same order of intensity as the calcium lines. More detailed spectrophotometric measures are required for the elucidation of this problem, and some measures have now been made by Beals (*M.N.*, 93, 585) with this object in view. He finds that in both ξ Persei and 9 Camelopardalis the interstellar sodium lines are equal to or slightly stronger than the calcium lines.

Selective absorption by small particles of interstellar matter, giving rise to the relation between colour excess and distance, has continued to receive attention. Zug (*L.O.B.*, No. 454) has investigated the changes in this relation with galactic longitude, using the magnitudes, colour indices and spectra of individual stars in 23 open galactic clusters. The distance effect is very marked, but varies with galactic longitude, and the author regards a formula of the type

$$\text{Colour excess} = -0{\cdot}10 + 0{\cdot}36r + 0{\cdot}07r^2 \sin (117^\circ - L)$$

as preferable to a linear relation which assumes a uniform distribution of the absorbing matter. This matter appears to thin out beyond a distance of 2000 parsecs, since adjacent clusters at distances of 2000 and 4000 parsecs give similar mean values of colour excess.

Axial Rotation.—Theoretical work has been done by Carroll (*M.N.*, **93**, 478, 680) on the effect of axial rotation on line contours. He has shown the possibility of deducing, by a suitable analysis of observed line contours, both the original or "true" form of the line and the fact (if present) of distortion by rotation. In other words, the speed of a star's rotation may be found from the observed shape of a line without any assumption as to its "true" form. This method of analysis has been applied by Carroll and Miss Ingram (*M.N.*, **93**, 508) to three stars (44 Ori, 44 Per and 39 Ori) with very satisfactory results, which agree reasonably well with those of Struve and Elvey. The method is thus shown to be perfectly practicable and capable of considerable precision, a fact which is confirmed by their analysis of the *MgII* 4481 line in Algol. A published contour of this line by Elvey was used, yielding a rotational velocity in perfect agreement with a value obtained by Rossiter and McLaughlin from radial velocity observations.

Christine Westgate (*Ap. J.*, **77**, 141; **78**, 46) has made a statistical study of the line widths of *MgII* 4481 and *HeI* 4472 in 275 B-type stars. These widths were transformed into equatorial rotations by correlation with Elvey's values for the latter in the same stars. A theoretical frequency curve was then constructed by trial and error (with due regard to the probable distribution of axial inclinations), which best fitted the observed frequencies of rotation. It appears that 53 per cent. of the stars have an equatorial velocity of 100 km./sec., 27 per cent. have 50 km./sec., 15 per cent. 150 km./sec. and the remainder 200 to 250 km./sec. A similar investigation of A-type stars yields a more even distribution of equatorial velocities between 25 and 150 km./sec., with about 12 per cent. greater than 150 km./sec.

The rotation effect in eclipsing binaries is a useful, though limited, method of obtaining rotational velocities from direct radial velocity measures. The method is based on the asymmetrical broadening of the spectral lines when one limb of the primary star is hidden near the time of eclipse. It forms a useful means of checking the deductions from line contours as mentioned above. The method of extracting this effect from a series of radial velocity observations has been described by Rossiter (*Pub. Mich. Obs.*, 5, No. 6) and applied by him to the case of β Lyræ. It is interesting to note in passing that after this effect has been eliminated the observations conform satisfactorily to undisturbed elliptic motion, and no assumption of a third body is required to explain the motions of this system. McLaughlin (*Pub. Mich. Obs.*, 5, No. 7) has similarly investigated the orbit of α Coronæ Borealis and demonstrated the existence of a rotation effect from which he deduces an equatorial velocity of the order of 100 km./sec.

Spectroscopic Parallaxes.—Work on spectroscopic parallaxes has been continued at Harvard by Öpik and Olmsted (*H.C.*, 380), who have obtained

the absolute magnitudes of 792 early-type stars from the total intensities of the hydrogen lines. The reduction curves were based on proper motion and radial velocity, the zero points being corrected for the selection error caused through choosing stars by apparent magnitude instead of by volume of space. By assuming the dispersion of true absolute magnitudes round a given spectroscopic value to be $\pm$ 0·68, the frequency distribution of absolute magnitudes yields a probable true distribution which is in general agreement with Strömberg's data for the same spectral range.

The correlation between hydrogen-line intensities and luminosity may be due to various physical causes, amongst which the Stark effect has been suggested. Öhman (*Stockholm Obs. Pub.*, **11**, No. 10) has investigated this by measuring the continuous hydrogen absorption in the Pleiades stars. Although this is unlikely to be influenced by the Stark effect, it shows a marked correlation both with line intensities and with luminosity. Öhman suggests that both these quantities are primarily accurate measures of temperature, and the luminosity relation is due to obtaining a refined Hertzsprung-Russell diagram.

The papers by Plaskett and Pearce (*Pub. D.A.O.*, **5**, No. 3) on interstellar calcium, and by Morgan (*Ap. J.*, **77**, 291) on absolute magnitude effects, which are referred to elsewhere, have considerable bearing on the question of spectroscopic parallaxes. The former gives an independent direct method of obtaining parallaxes of early-type stars with an individual accuracy at least equal to that of most other methods.

Miscellaneous.—The problem of a detailed classification of stellar spectra has been discussed by Struve (*Ap. J.*, **78**, 73), who points out the difficulty of merely refining a simple linear sequence such as the Harvard classification, on account of the disagreement of the different criteria used. Two stars of the same temperature and pressure do not necessarily have identical spectra. Some other factors controlling the appearance of a spectrum must exist, amongst which it is suggested that variations in the relative abundance of different elements may be important. B-type stars are considered in detail, and the use of *HeI* 4472 as the fundamental criterion for type is proposed. A study of the variations of other lines (such as *H*, *HeII* and *MgII*) might then lead to a separation of the different factors which are present. A somewhat similar study of peculiarities in stellar spectra of types B8 to F0 has led Morgan (*Ap. J.*, **77**, 330) to suggest a special branch of the spectral sequence over this range, which is intermediate between the giants and dwarfs, and in which the various groups of peculiarities can be arranged in order of decreasing ionisation. These groups include the *MnII* stars, stars of the θ Aurigæ type (λ 4200 well marked), *EuII* stars, *CrII* stars and *SrII* stars in that order.

Morgan (*Ap. J.*, **77**, 241) has also studied absolute magnitude effects in the case of some of the lines of *MgII*, *FeII*, *CrII* and *TiII*. All four of these elements show a pronounced absolute magnitude effect at temperatures below that of their maxima (B5 for *MgII* and B8–A0 for the other elements), though at higher temperatures there is a null effect. This

absolute magnitude effect reaches a maximum at types F5 in each case, and then again diminishes for later types. In the case of *BaII* and *FeI* there are similar absolute magnitude effects, but without a null effect at higher temperatures.

Amongst stars which have received detailed individual attention may be mentioned 73 Draconis, studied by Morgan (*Ap. J.*, 77, 77), and τ Scorpii by Struve and Dunham (*Ap. J.*, 77, 321). The former is regarded as a typical "chromium star," with a weak [K] line and very strong lines of *CrI* and *CrII*. It is a spectrum variable in which *EuII* (λ 4205), some *FeII* and *TiII* lines, and possibly a number of other lines vary in intensity over a period of 20·7 days. D. L. E.

Stellar Motions, 1932–1933

(An asterisk denotes publication in 1933)

There has been a considerable accumulation of literature since the appearance of the last Council note, and it is impossible to give more than a very brief review. An outline of the present state of the subject will be found in Lindblad's valuable chapter, *Die Milchstrasse*, in *Handb. d. Ap.*, 5 (2)*.

Galactic Rotation.—This continues to provide a major incentive to the study of stellar motions, and most of the work aims at discovering to what extent the Lindblad-Oort theory suffices. On the one hand, there is the possibility that motions in the galaxy, though reasonably unitary, are expansive as well as rotational; on the other, that the local cluster has a distinct dynamical, as opposed to a merely distributional, importance, or even that we have to deal with a supergalaxy. Moreover, if the Lindblad-Oort theory be accepted, there is still considerable uncertainty as to the values of the appropriate constants.

The first of the above hypotheses is made in a paper by Pilowski (*A.N.* 5922*). He supposes that the systematic velocities in the galaxy are symmetrical about the galactic plane and axis, but that they may depend on distance z from the galactic plane as well as on distance from the galactic axis, and are not necessarily transverse. He then works out the effect to be expected in radial velocity and proper motion, to the first power of distance r from the Sun parallel to the galactic plane, but to higher powers of z. He thus manages to account for a systematic trend in the residuals from Mineur's "second asymmetrical drift"; the Sun has to be placed well over 100 parsecs north of the plane of symmetry. The explanation involves a rather rapid variation of expansive velocity with z; perhaps this might not have been expected *a priori*, but it provides an obvious interpretation of the drift in question. It should, however, be noticed that the reality of the second drift has been questioned. Thus it is not found by J. M. Mohr (see below); Mineur considers that no contradiction arises here, as Mohr's data are not well adapted to test the matter, and he himself, with two collaborators, confirms the existence of the drift by means

of space-velocities of giants (*C.R.*, **195**, 208). But Bertaud also fails to find the drift (*C.R.*, **197**, 1098*).

In *Z.f.Ap.*, **4**, 396, Pilowski elaborates a point from an earlier paper on galactic expansion, while in *A.N.* 5977* he considers to squares and higher powers of r the effect of an assumed expansion on radial velocities; he also finds preliminary reasons for thinking that, on the expansion hypothesis, the deviation of Oort's l_0 from the longitude of the galactic centre would be about half the similar deviation for the vertex of star-streaming, in good agreement with the assumed facts.

The possibility of galactic expansion has sometimes been mooted merely by analogy with the expansion of the universe, but the circumstances are widely different, and it is not yet established, either that the galaxy is expanding, or that any kind of repulsive force is a necessary ingredient in the general explanation of stellar motions.

With particular reference to the B stars, Ogrodnikoff gives, in *Z.f.Ap.*, **4**, 190, a general theory of motion, including Oort's as a particular case. He then deduces results somewhat similar to those of von der Pahlen and Freundlich, in that the Sun is imagined to be moving in a very elongated ellipse, more nearly towards the galactic centre than transversely. An explanation of the vertex-deviation is proposed. The acceptance of the reality of the K-effect for the nearer B stars, a rather limited phenomenon, is fundamental in the extended theory. The applicability of the analysis has, however, been contested in a paper by Bottlinger (*Z.f.Ap.*, **6**, 150*) and incidentally by others. Ogrodnikoff replies to Bottlinger on p. 154.

A critical review of existing theories, based on the proceedings of a two-day colloquium on stellar motions at Göttingen, is given by Pilowski and by Wachtl, *Himmelsw.*, **42**, 226, 244, while Heckmann (*V.J.S.*, **68**, 322*) gives a preliminary account of some work on the theory of dynamically steady systems.

The space-velocities of 1678 stars are analysed by J. M. Mohr in an extensive paper (*M.N.*, **92**, 562), with results favourable to the Lindblad-Oort theory. See also a note by Strömberg, *ibid.*, 886. A paper by Mineur (*Bull. astr.*, **7**, 383*) first reviews the more important previous work. The author contends that Mohr's results are compatible with a rotation about the local centre. He then outlines several new methods for the study of galactic rotation, all involving consideration of the systematic space-velocity (X, Y) parallel to the galactic plane as a function of position (x, y); such methods are, of course, best suited to the treatment of reasonably near stars. The results of some computations along these lines are briefly communicated by Mineur and Guintini, *C.R.*, **194**, 61; so far as can be judged, they are more compatible with rotation about the local than about the galactic centre.

In *Publ. D.A.O.*, **6** (5), Redman gives the final results of his radial-velocity observations of all K stars with visual magnitudes between 7·0 and 7·5, north of declination $-10°$ and within 10° of the galactic equator. An analysis for Oort's constants yields abnormal second harmonics; in particular, the centre falls well inside the first quadrant of galactic longitude.

In this connection the author draws attention to the anomalous results that have been obtained from stars within some 350 parsecs of the Sun. The discrepancy, as far as Redman's data are concerned, is largely cleared up by Nordström (*Ark. M.A.F.*, **23**A (14)*, *Lund Medd.* (1), 131), who shows that normal results may be procured by taking the systematic velocity in each region to be the mode (after drastic smoothing) instead of the mean of the individual velocities. The process impairs the obviousness of comparison with other results, but this is perhaps unimportant. The motions of late-type stars are discussed by Mlles. Canavaggia and Fribourg (*C.R.*, **197**, 1194*).

L.O.B. 448 contains an interesting work by Miss Hayford. After giving general expressions for the harmonics up to the sixth, on the basis of Oort's hypothesis, she analyses the radial velocities of 25 open clusters. These are distributed over 255° in longitude, and their distances as estimated by Trumpler, allowing for absorption, range from 940 to 3360 parsecs. The solar velocity in all solutions is about 30 km./sec., and the amplitude of the third harmonic is some two-thirds of that of the second. This is due to the unexpected smallness of the latter rather than to undue size of the former. A fourth harmonic is computed, but the improvement in representation is small. The agreement between the values of l_0 found from the three different harmonics is striking, but surely highly fortuitous. If the values for the second and third harmonics were to be exactly confirmed, we should have to suppose the galactic centre rather near; Miss Hayford's estimate that it would have to be well within 6000 parsecs is reasonable. But the uncertainty of the results is considerable, and we may perhaps be satisfied that the second harmonic is of the same general nature as that given by other groups. A result of 1800 parsecs for the distance to the centre, estimated by another method, is very uncertain, as Miss Hayford recognizes.

An article on galactic rotation by Bottlinger (*Ergebn. d. ex. Naturwiss.*, **11**, 31) gives the higher harmonics explicitly as far as terms of order r^3 in the coefficients for the case of inverse-square attraction, and also some fresh statistics on the true galactic concentration of stars of various classes. An illuminating review is given by Lindblad (*V.J.S.*, **68**, 52*). Bottlinger also devotes *Babelsberg Veröff.*, **10** (2)* to divers rotational topics. As basis for a numerical evaluation of the rotational effect at various distances he now uses an empirical law of force in the galactic plane; instead of supposing with Oort that the distribution of mass in the galaxy can be simulated by a spherical nucleus and a homogeneous ellipsoid, so that the force is of the form $K_1/R^2 + K_2R$, he selects the form $aR/(1 + bR^3)$, and uses two different values of the constant b. The rest of the work deals among other things with galactic concentration and with the radial velocities of the planetary nebulæ and of Miss Hayford's open clusters.

Joy has used the radial velocities of 124 Cepheids in a study of absorption and galactic rotation (*P.A.S.P.*, **45**, 202*). Gerasimovič has a note in *Poulk. Circ.* 1 on the distance to the centre, while the values of Oort's constants are considered by Lindblad in *Scientia*, 1932 May (*Stockh. Medd.* 7).

Frl. Nowacki examines in *A.N.* 5860 the effect of the recent revision of Auwers' *N.F.K.* on the rotational constants deduced by Holm from the Lund A.G. zone. The large value previously found for A is hardly altered, that for $-B$ is considerably reduced, but the latter determination is, of course, not absolute. The relation between galactic rotation and precession is discussed by Pilowski (*A.N.* 5864). Shajn suggests (*Poulk. Circ.* 7*) that integrated radial velocities of galactic clouds could be obtained with sufficient accuracy to throw light on the rotation.

Distributional methods, overhung as they are, in F. Becker's words, by the Damocles' sword of absorption, continue to give uncertain values for the distance to the centre. Using globular clusters and considering absorption, Stebbins reduces it to some 10 kiloparsecs (*P.N.A.S.*, **19**, 222*); but he and Huffer (*ibid.*, 597*) think that the distance may have to be increased again, as most of the clusters so far believed to be beyond the centre may be on this side of it. Galactic dimensions are discussed by Shapley with the help of cluster-type Cepheids in *P.N.A.S.*, **19**, 29* (*H.R.* 81).

An important contribution to the study of galactic rotation is made by J. S. Plaskett and Pearce, *Publ. D.A.O.*, 5 (3)*. Their discussion is based on a catalogue of 314 stars with interstellar lines. For each star is given the interstellar and, when obtainable, the stellar velocity, along with a careful estimate of the interstellar intensity. This catalogue makes possible an extension of the work already done by the same authors with part of the material. The stars are divided into two distance-groups by means of the interstellar intensities, and the interstellar velocities are then analysed. Assuming, to stabilize the solution, a zero K-term, the authors find a normal solar motion, indicating that the matter is at rest relative to the stars as a whole, while the groups agree in giving 331° as the longitude of the centre. Other solutions show a regular increase of rotational term with intensity, and an excellent two-to-one ratio between the terms from stars and from matter. The authors nevertheless find evidence of considerable local irregularities in interstellar distribution. They also try to find values of A from various groups by working out provisional mean parallaxes with the help of proper motions; considering the smallness of these, the attempt is not altogether unsuccessful. Rotational workers will naturally wish to supplement the large amount of computation performed for them by still more computation, and will be grateful for the catalogue of individual data. The general inference from the work is that, at least as far as the radial velocities are concerned, considerable regularity of motion, of a kind compatible with Oort's hypothesis, extends for some 2000 parsecs from the Sun in the directions considered. Unfortunately, part of the value of Plaskett and Pearce's data must remain latent, so long as complementary data for the southern sky are lacking. Further work on the motions and mean parallaxes of early-type stars is reported by the same authors (*P.A.S.P.*, **45**, 207, 208*).

The amount of support forthcoming for the Lindblad-Oort theory tends to raise the question of the status of the local cluster. Various workers

on stellar distribution have argued that the observed decrease of star-density with distance is too great to be explained mainly by absorption, though the existence of much "discontinuous" absorption of the type studied by Bottlinger (*Z.f.Ap.*, **5**, 50) would affect the conclusion, and other objections have been raised. A certain amount of clustering would, however, have little dynamical importance, and the interesting question is whether our cluster can hold itself together by its own attraction. Both its internal velocity-distribution and the tidal effect due to the gradient of the general galactic field might disperse it. Exact calculation is impossible at the moment, but it seems on the whole doubtful whether our cluster could resist either of these tendencies separately, and somewhat unlikely that it can resist their joint action. Bottlinger, however, who had previously thought the cluster not dense enough to withstand the tidal effect, points out (*Babelsberg Veröff.*, **10** (2), 35*) that a small density might suffice ; for the Sun may be fairly near the ring of maximum attraction and thus of vanishing tidal force. He thinks it probable that this ring is somewhat nearer than the Sun to the galactic centre, and suggests that the Sagittarius cloud may owe its existence to this cause. Lindblad appears definitely to regard the cluster as unable to hold itself together (*V.J.S.*, **68**, 46*). If this is so, the cluster will be scattered along its orbit in a fraction of its period of galactic revolution, and Lindblad, in the course of a paper on the dynamics of rotating stellar systems (*Ark. M.A.F.*, **23**A (18)*, *Stockh. Medd.* 11), pictures the cluster as "a semi-permanent, now practically dissolved condensation," the Cygnus and Carina clouds representing the parts scattered in the front and rear respectively. See also a series of articles on stellar astronomy by Mineur (*L'Astr.*, **46**, 17, 404, 465).

The recognition of an absorbing layer near the galactic plane has enormously increased the difficulty of obtaining information of even the roughest kind concerning the density-function in low latitudes. It seems more feasible at the moment to establish the variation of the distributions of luminosity, spectral type and velocity with height z above the galactic plane. A certain amount of work has already been done in this direction, but not with the wealth of detail employed by Oort in an important and extensive paper in *B.A.N.* 238. It is hardly possible to summarize here the two-page summary by the author, except to say that the main theme of the paper is the gravitational force-component K at right angles to the galactic plane. This is found to vary nearly linearly with z for distances up to about 200 parsecs, so that the z-motion of a star within these limits is nearly simple-harmonic, with period about 84 million years. The force then varies more slowly up to about 500 parsecs, and some idea of its behaviour at greater distances is obtained.

Solar Motion and Star-streaming.—In *Bull. astr.*, **7**, 321 (errata 421), H. and Mme. Mineur work out in full detail the corrections to a velocity-ellipsoid computed from radial velocities freed from preliminary solar motion, when it is desired to take account of K-term, galactic rotation and a different solar motion. The authors then apply these corrections to velocity-ellipsoids computed by them for stars in various groups of spectrum

and distance. They next consider the variation of mean peculiar velocity with position ; the result is not very definite, but they consider that there may be an increase of mean velocity in the direction of the anticentre. Finally, they analyse the peculiar radial velocities for third harmonics, which, as far as motions parallel to the galactic plane are concerned, turn the velocity-ellipse into a kidney-shaped curve like that of Strömberg ; its interpretation is discussed. Mineur writes on similar lines in *C.R.*, **195**, 30. A point of technique in the computation of velocity-ellipsoids is discussed by Robb, *Lund Medd.* (1), 133.

Polar frequency-diagrams for proper motions in four photographic regions are given by Miss White, *M.N.*, **92**, 519 ; **93***, 105, 647. In *Rend. Lincei* (6), **17***, 497, 601, 882, 1025, Bemporad gives the larger proper motions in four photographic regions, and analyses them into numerous streams. Proper motions for 117 stars, mainly red variables, are given by Miss Palmér, *Lund Medd.* (2), 66.

The motions of A stars are discussed by Bertaud (*C.R.*, **197**, 905*), and those of long-period variables by P. W. Merrill (*Pop. Astr.*, **41**, 188*).

A solution by Zagar (*Mem. Soc. Astr. Ital.*, **6**, 521*, *Padua Publ.* 30) for K-term and solar motion without galactic rotation from radial velocities of 998 B stars yields ($+1{\cdot}7$; 21·7, 271°, $+39°$). Solutions for solar motion from radial velocities are also made by Edmondson (*A.J.* 988*) for stars of various apparent magnitudes, and in a pamphlet by Tibor (*The Elements of the Solar Motion*, Hungary) for stars fainter than $4^{m}{\cdot}5$ of various spectral types.

Moving Clusters.—The Taurus cluster and the wider Taurus group are investigated with some fresh material by R. E. Wilson (*A.J.* 978). He gives lists of 136 cluster and 221 possible group stars ; only 58 would be expected in the latter by chance. A slight systematic deviation from uniform stream-motion is noticed. The Scorpio-Centaurus cluster is discussed by F. D. Miller in *H.B.* 886 and in *P.N.A.S.*, **19**, 277* (*H.R.* 86). The proper motions confirm Kapteyn's conclusion that the peculiar motions are small ; the radial velocities, even after allowing for normal observational uncertainty, show a larger scatter, and Miller infers the existence of errors common to all radial-velocity observers. The work of Kaburaki (see the 1932 Council note) is continued in *Jap. J.A.G.*, **10**, 313*, while Gyllenberg investigates in *Lund Medd.* (1), 132 the systematic motions of binary as compared with single stars, and finds little difference. Bertaud has a series of articles on moving clusters in *L'Astr.*, **47***, 112, 172, 216.

Mean Parallaxes and Luminosities.—Strömberg assembles his results for the luminosity-distributions of the naked-eye stars of various spectral types in *Ap. J.*, **75**, 115 (*M.W.Ct.* 442). He distinguishes five discrete luminosity-sequences (supergiant, bright, normal and faint giant, and main). He finds some confirmation from trigonometric parallaxes in *Ap. J.*, **78**, 178* (*M.W.Ct.* 473).

Öpik and three collaborators (*H.C.* 381*) contend that the integral-equation method of van Rhijn and Strömberg neglects an important fact, that the radial velocities and proper motions correspond in pairs. Using

a method stated to have about three times as much resolution, they find a Russell diagram showing various luminosity-sequences, which they say have little in common with Strömberg's. Schilt (*M.N.*, **92**, 137) shows that a luminosity-distribution with several maxima found for the B stars by Gerasimovič, using the integral-equation method, can be satisfactorily replaced by one with a single maximum. R. E. Wilson investigates in *A.J.* 968 the luminosities of the naked-eye stars on the basis of known parallaxes of various kinds.

Strömberg's results for late-type stars are reduced to unit volume by Oort, *B.A.N.* 239. The results for the K stars do not agree well with those of van Rhijn. Oort also discusses the allowance for star-streaming when mean parallaxes are computed from peculiar motions. He works with quadratic mean velocities, Fletcher (*M.N.*, **92**, 780) with linear ones. Another computation of the luminosity-distribution for the naked-eye K stars is made by Gratton (*B.A.N.* 248*). Some of the points involved are considered by Strömberg (*M.N.*, **94**, 68*). Edmondson writes in *A.J.* 974 on the mean parallaxes of the stars of the first six apparent magnitudes, and in *A.J.* 981 on their representation by empirical formulæ.

The Cepheid period-luminosity zero-point, to which positive corrections have often been deduced, is investigated by Mrs. Fairfield Bok and Miss Boyd (*H.B.* 893*). Proper motions of 43 cluster-type variables are found from small-scale Harvard plates and a long time-interval, with the help of some astrographic material. Using these and 15 other proper motions, reduced but unweighted, and Strömberg's solar motion from 26 radial velocities, the authors find a negligible positive correction. Many more radial velocities have been obtained at Mt. Wilson (Joy, *P.A.S.P.*, **44**, 240). The view that the zero-point needs little correction, and that his own result from classical Cepheids is due to absorption, has recently been adopted by Gerasimovič (*Obs.*, **57**, 22). Lundmark, in an investigation of high luminosities, finds a strongly negative correction to the Cepheid zero-point (*V.J.S.*, **68**, 369*). He also suggests in *Lund Circ.* 7 that the luminosity be regarded as correlated not merely with the period but with numerous characteristics.

Proper motions for 21 planetary nebulæ are given by van Maanen in *Ap. J.*, **77**, 186* (*M.W.Ct.* 463). He finds a mean absolute photographic magnitude of +1·9 for the central stars. Miss Hoffleit finds that the carbon and nitrogen Wolf-Rayet stars have proper motions of about the same size and hence are presumably at about the same distance ; in this case the carbon stars are the fainter by some two magnitudes (*H.B.* 892*). The absolute magnitudes of the hotter stars are examined by Pearce (*P.A.S.P.*, **44**, 261) on the basis of distances derived from interstellar intensities. A. FL.

Variable Stars, 1933

Instrumental.—Steady improvement in the technique of measuring the apparent magnitude of a variable star has continued throughout the year. Sinclair Smith (*Phys. Rev.*, **43**, 211) * has described a very sensitive stellar

* The date of all references is 1933 unless otherwise indicated.

photometer which has been used at the Coudé focus of the 60-inch reflector at Mt. Wilson. A quartz photoelectric cell is mounted in conjunction with a Hoffmann electrometer, leaks being eliminated by evacuating the surrounding space. Photoelectric currents down to 30 electrons/sec. have been measured, but routine work has been confined to stars brighter than 14^m, which give approximately 500 electrons/sec. Below this limit observations are made inconveniently slow on account of the necessity of waiting to smooth out the irregularities in the electron emission.

Two investigations have been made into questions bearing on the use of photoelectric cells in stellar photometry. Löhle (*Z.f.Ap.*, **6**, 293) has discussed the sensitivity attainable with certain commercial vacuum cells (cæsium), particularly when a thermionic amplifier is used. Difficulty is created by the large dark current of these cells, which may be reduced by cooling in liquid air, but this leads to a general loss of sensitivity. It is concluded that reproducible sensitivity and accuracy cannot be reached with cells of this kind. Janssen (*Z.f.Ap.*, **7**, 249) has made investigation into the fatigue effect shown by gas-filled photoelectric cells, which has hitherto made them unsuitable for photometric use, despite their considerable advantages in sensitivity over vacuum cells. The "fatigue" is shown to depend on the purity of the materials used in preparing the cell. Employing potassium and argon which had been very carefully purified, it was possible to avoid these effects entirely. Deposition of potassium hydride on the cathode made the trouble reappear, while the deposition, on top of this, of a thin layer of metallic potassium removed the effect once more. The fatigue-free cells did not obey the proportionality law.

The photoelectric photometer used at the Cambridge Observatory has been described by Smart (*Observatory*, **56**, 75). It embodies a Lindemann electrometer, and readings are obtained by a null method. The mean from 4 or 5 observations has a probable error about $0^m.002$ under normal conditions (*Observatory*, **57**, 8, 1934).

For photographic work a "Schraffierkasette," in which extra-focal images may be enlarged and made uniform by means of an oscillating motion of the plate on which they are recorded, has been built for the Mt. Wilson 60-inch reflector (Christie, *Ap. J.*, **78**, 313). Measures of magnitudes derived from the densities in such images are free from troubles due to irregularities in the plate or to lack of uniformity in the extra-focal images and are claimed to be of high accuracy. Another method of dealing with the irregularities of extra-focal images found particularly in Newtonian reflectors has been put forward by Oberguggenburger (*Sitz. Akad. d. Wiss. in Wien*, II*a*, **142**, 103), who uses a thin diffusing screen placed immediately in front of the plate.

A modified Schilt photometer, in which the photographic plate is mounted horizontally instead of vertically and a Weston photronic cell is used in place of a thermopile, has been constructed by Bennett (*Ap. J.*, **78**, 305).

Eclipsing Variables.—The spectrum of β Lyræ has been the object of a detailed investigation by Miss Maury (*H.A.*, **84**, No. 8), using 307 objective-prism spectrograms. A relative spectroscopic orbit is calculated and

discussed together with the intensity changes of the emission and absorption spectra. The phenomena are interpreted as due to an eclipsing binary of small separation, each component being surrounded by a tenuous envelope. Evidence is presented to show that different lines arise predominantly at different atmospheric levels, the emission lines arising at least partly in the envelopes. Some of the spectral changes are traced to variations over the surfaces of the two stars, chiefly in the regions of each component which are nearest to and farthest away from the companion. There are prominent and unexplained irregularities superposed on the periodic spectral changes. Radial velocity measures of the B8 spectrum, covering the years 1911–21, have also been published (Rossiter, *Pub. Obs. Univ. Michigan*, 5, No. 6), and have served for the calculation of a spectroscopic orbit. The velocity of the centre of mass is constant, negativing the possibility of the presence of a third body in the system, and there is a very well-marked effect at principal eclipse due to the rotation of the star. This rotation effect was also observed by Miss Maury. It may be noted in passing that a rotation effect has been measured also in α Coronæ by McLaughlin (*Pub. Obs. Univ. Michigan*, 5, No. 7). The problem of β Lyræ has been considered also by Tscherny (*A.N.*, **249**, 205 ; **250**, 9).

During the course of measures of the radiation of various stars by means of a vacuum thermocouple, used at the Newtonian focus of the Mt. Wilson 100-inch reflector, Pettit and Nicholson (*Ap. J.*, **78**, 320) found that the temperature difference of the two components of Algol is too small to be determined by their method, which relies on the comparison of total radiation with that transmitted by a water-cell, suitable corrections being made for absorption in the Earth's atmosphere. The radiometric range of this star is $0^{m}\cdot12$ less than the photoelectric range, and the radiometric magnitude is brighter than the photoelectric magnitude throughout primary minimum, which indicates that the occulting star is probably of lower temperature than its companion.

An addition has been made to the short list of eclipsing binaries whose orbits have a rotating line of apsides (Shapley and Keller, *H.B.*, **893**, 6). YY Sgr has a period of 2·628 days, with orbital eccentricity 0·10 and a period for the apsidal rotation of about 200 years. The components are practically identical with each other. Luyten (*P.A.S.P.*, **45**, 297) has given a list of eclipsing variables and spectroscopic binaries in which conditions seem favourable for the occurrence of this orbital phenomenon, assuming it to be related to the distribution of density within the components, and where an examination of the orbits with this end in view might be worth while.

Photoelectric measures of ϵ Aurigæ have been made by Fraülein Güssow (*A.N.*, **250**, 73), who discusses the secondary oscillations shown by this star in both magnitude and radial velocity. A comparison of spectral line intensities in this star with those in the similar spectrum of 17 Leporis has been made by Hynek (*Ap. J.*, **78**, 54). Strong lines are of the same order of intensity in the two stars, but the fainter lines are much weaker in 17 Leporis. Six *TiII* multiplets were measured, the intensities showing a

rather large scatter both in comparing the stars and in comparison with theoretically predicted values. Measures of the colour index of ζ Aurigæ, a binary resembling ε Aurigæ, were carried out, during the eclipse of 1932 and subsequently, by Hopmann (*Berichten der Math.-Phys. Klasse d. Sachsischen Akad. d. Wiss. zu Leipzig*, **85**, 117). It is important that this star should be observed both photometrically and spectroscopically throughout the forthcoming eclipse of 1934 September.

Walter (*A.N.*, **250**, 333) has made photovisual observations of U Cephei, whose light variation shows features which cannot be explained on the basis of an ordinary eclipsing pair. The eccentricity of the photometric orbit is small, while that of the spectrographic orbit is as high as 0·474. The star consists of a small bright A-type component with a large, relatively faint K-type companion. The unexplained irregularities are traced to the latter, and Walter seeks to elucidate them in terms of a libration of this component.

The surface temperatures of a number of eclipsing binaries have been computed from their photometric orbits and trigonometrical parallaxes by Gaposchkin (*A.N.*, **248**, 213). There is satisfactory agreement with colour temperatures. Several papers dealing with various aspects of the determination of photometric orbits have been published by Krat (*Verein von Freunden d. Physik und Astronomie in Gorki* (*Nishni Novgorod*), **4**, 97 ; *M.N.*, **94**, 70 ; *Z.f.Ap.*, **6**, 96). He considers the reflection effect and darkening to the limb and also the problem of derivation of orbital elements when the eccentricity is large.

A theoretical study which should have an important bearing on questions relating to eclipsing binaries has appeared in papers by Chandrasekhar (*M.N.*, **93**, 390, 449, 462, 539) on the equilibrium of polytropic gas spheres when distorted by rotation or by the attraction of a companion, or by a combination of these. The changes of central density and of external dimensions are worked out, in cases where the distortion is not too large, for various polytropic indices between 0 and 5. Investigations by Jeans, Milne and von Zeipel some ten years ago showed that in a star distorted by rotation or by tidal action there is a variation of brightness over the surface directly proportional to the variation of apparent surface gravity. In this connection Chandrasekhar calculates the apparent gravity variations over the surface of his distorted polytropes. (It may be pointed out that this gravitational effect, leading to a variation of radiation over the surface of an eclipsing variable component, does not seem generally to have been accorded the attention it deserves.) The applicability of the polytropic approximation to this problem has been questioned by Eddington (*Observatory*, **56**, 218).

Novæ and Related Stars.—The variable RS Ophiuchi, which was observed as Nova Ophiuchi 3 in 1898, was subject to another outburst in 1933 August. Its resemblance to T Pyxidis, which has also had repeated outbreaks of a similar nature, has been commented on, and at least two writers have noted that it seems quite probable that there is a class of recurrent novæ, a very important fact if verified.

The brightness during the present outbreak was at maximum $4^{m}\cdot3$

(August 12) and declined rather quickly to $9^{m}.9$ at the beginning of October. Spectroscopic observations have been published by several observers. A photograph taken at Mt. Wilson in 1923 showed strong bright lines of $H\beta$ and $H\gamma$ with faint emission lines of ionised iron. The continuous spectrum was strong with faint absorption lines and was classified G5. The radial velocity, chiefly from the hydrogen lines, was −35 km./sec. Spectra taken at various observatories during the recent maximum showed at first an appearance somewhat similar to this early observation. The changes which later took place can be characterised as nova-like, although not typical of a nova. In particular, the velocity displacements of the absorption lines were not of the large size usually observed. A very interesting feature has been the appearance, during the later stages, of the coronal lines λλ 3987, 4086, 4231, 5303 and 6374, which were found on Mt. Wilson spectrograms. Despite the necessity for using a low dispersion instrument, the identifications seem well established. The questionable coronal line λ 5535 appears as a faint line on spectrograms obtained after September 8. The nebular lines, which had appeared about a week after maximum, later grew fainter, and the last observations showed them very weak (Loreta, *A.N.*, **249**, 404 ; Ellsworth, *A.N.*, **250**, 71 ; Adams and Joy, *P.A.S.P.*, **45**, 249, 301 ; Wright and Neubauer, *P.A.S.P.*, **45**, 252 ; McLaughlin, *Pub. Obs. Univ. Michigan*, **5**, No. 9 ; Westgate, *Ap. J.*, **78**, 372 ; Müller, *A.N.*, **249**, 404 ; **250**, 143 ; Spencer Jones, *Observatory*, **56**, 332 ; Campbell, *H.B.*, **893**, 9).

Spencer Jones (*M.N.*, **94**, 35) has described the 1933 spectrum of N Pictoris 1925. The continuous spectrum is increasing in intensity and the brightest emission line is now λ 4686 *HeII*. The two unknown lines λλ 5723 and 6088 have changed in relative intensity, evidence against a common origin. There are no lines of *HeI*. Following recent identifications by Boyce, Menzel and Payne (see below), it is suggested that fluorine is very abundant in this star. Jones disagrees with the identifications proposed by Stratton (*Observatory*, **56**, 26) for the lines λλ 4620, 4944 and 4989, on the ground that they involve large line-displacements for which there is otherwise no evidence in this spectrum.

Spectra of the former nova, η Carinæ, have been examined by Miss Hoffleit (*H.B.*, **893**, 11). In 1895 the spectrum showed prominent bright lines, the stronger ones with conspicuous absorption on the violet side. Later the forbidden *FeII* lines increased in strength relative to $H\gamma$, but since 1902 there have been no noticeable changes in the spectrum. The paper contains a list of newly identified lines. The same author (*H.B.*, **892**, 19) has also found that of 10 known P Cygni stars in the Large Magellanic Cloud 2 are variable in magnitude, while of 20 galactic P Cygni stars 8 are variable.

Boyce, Menzel and Miss Payne (*Proc. Nat. Acad. Sci.*, **19**, 581) have discussed the problem of forbidden lines in astrophysical sources. They point out that novæ form a rich field for the study of forbidden transitions, since they effectively run through stages corresponding to a series of nebulæ arranged in order of increasing excitation, and probably of decreasing

density. A number of new identifications are made. λλ 3868 and 3969, which are strong in most nebulæ and occur in many novæ, are attributed to *NeIII*. Two other lines occurring in both nebulæ and novæ are λλ 3342 and 4724, whose sources are identified as *NeIII* and *NeIV* respectively. λ 5723, a prominent line in N Pictoris, also seen in N Aquilæ 1918, has been attributed to *FIII*, while two other lines are tentatively traced to *FII*.

In a succeeding paper (*Proc. Nat. Acad. Sci.*, **19**, 641) Menzel and Miss Payne inquire into the production of a nova spectrum by radiation from an expanding shell. It is supposed that at the time of the first outburst the photospheric layers are blown away from the surface of the star, which otherwise does not itself expand. The changes from an absorption line spectrum to a bright line spectrum developing nebular lines and ultimately showing Wolf-Rayet characteristics are associated with the expansion and diminishing density of a shell of gas thrown off in this manner. (The mass of such an ejected shell has been estimated by Ambarzumian and Kosirev as about 1/100,000 of the Sun's mass (*Z.f.Ap.*, **7**, 320).) Schematic line profiles are shown corresponding to various simple assumptions, although it is pointed out that the problem is not simply one of a single symmetrical outburst with ejection of atoms at a constant velocity. Emphasis is laid on the regular order in which absorption, and later emission, lines of increasing excitation energy appear. Forbidden *FeII* lines seem to be connected particularly with the more slowly developing novæ, where a sufficiently low density is reached before the temperature has increased so much as to ionise the *FeII* further. There appear to be variations of chemical composition both in novæ and in Wolf-Rayet stars, particularly with regard to carbon, a point which merits further consideration.

Cepheids and Cluster Variables.—A contribution to the question of the zero point of the period-luminosity curve is made by Mrs. Bok and Miss Boyd (*H.B.*, **893**, 1). They have measured proper motions of 43 cluster variables in the southern sky. Mean parallaxes were derived from these measures, and it is thence concluded that no appreciable correction is required to the revised zero of Shapley's relation. This is in conflict with results derived recently by Gerasimovič. The latter, however, points out (*Observatory*, **57**, 22, 1934) that his values were obtained from classical Cepheids lying in low galactic latitudes, while the proper motions just determined relate to objects with fairly high galactic latitudes. Hence it is reasonable to suppose the discrepancy to arise from absorption, which is known to occur in and near the Milky Way. It is pointed out that a complete solution of this zero-point problem must await the closer determination of the systematic errors of the fundamental systems of star positions.

Shapley and Miss Mohr (*Proc. Nat. Acad. Sci.*, **19**, 995) have completed a variable star survey in the Large Magellanic Cloud. About $1\frac{1}{2}$ per cent. of all supergiants between -1^m and -4^m are Cepheids, the concentration increasing up to 4 per cent. in the more crowded regions of the Cloud. The most numerous periods are 2^d–3^d, with no evidence of discontinuity at longer periods. It is held likely that extension of observation to fainter

objects will shift the maximum frequency farther towards shorter periods. The amplitudes show a wide dispersion, from one-half to two magnitudes, and have no correlation with luminosity or period. There is evidence for absorption of light within the Cloud in the vicinity of gaseous nebulæ.

According to Müller (*Veroff. d. Universitätssternwarte zu Berlin-Babelsberg*, **11**, pt. 1) the maximum frequency of the periods of variables in the globular cluster M3 is at $0^d.51$. Evidence for possible changes of period since the early observations of Bailey is slight, changes when observed being mostly in the direction of shortening period.

A large number of cluster variables has been found near 327°, $-18\frac{1}{2}°$, galactic co-ordinates, by van Gent (*B.A.N.*, 7, 21), who deduces that if they form part of a cloud of such variables situated around the galactic centre, the distance of the latter should be about 8400 parsecs.

In a paper already mentioned, Pettit and Nicholson have given results of thermocouple measures on η Aql and δ Cep. The water-cell magnitude, water-cell absorption and radiometric magnitude vary in phase with the visual magnitude, as expected on account of the fact that the energy maximum lies in the visible region of the spectra. The temperature variations were measured to be 670° and 800° respectively, while the calculated diameters are $0''.0021$ and $0''.0017$, with a range of about 15 per cent.

Colacevich (*Oss. e Mem. del R. Oss. Ast. di Arcetri*, No. 51) has observed monochromatic light curves and variations of intensity of $H\gamma$, $H\delta$ and the *G* band for U Aql and V 350 Sgr. Eye estimates of line intensities in the spectrum of δ Cep have been made by Ogrodnikoff (*Russian Astronomical Journal*, **10**, 304). He applies the Adams-Russell theory to the results, and finds a total temperature range of 400°, which he considers too small on account of observational errors.

If Cepheids are pulsating stars, it is desirable if possible to get direct observations as to the way in which their atmospheres pulsate, and in particular as to whether various atmospheric layers show differences between themselves. Petrie (*Pub. Obs. Univ. Michigan*, **5**, No. 3) has made a careful study of RT Aurigæ with regard to this point. As with other stars previously investigated by other workers, differential effects between various levels are slight, although in this case the author considers them to be real. He seeks a new criterion by which the lines may be classified to take the place of that actually used, which is the relative heights of the corresponding lines in the solar chromosphere. He suggests that optical depths computed from central intensities might serve. Woolley has criticised this (*Observatory*, **56**, 167), pointing out that the theory of the central intensities of lines is in a completely unsettled state and that the observed central intensities are in stellar work more closely correlated with line intensities than with anything else, on account of instrumental reasons.

In the theory of a pulsating star, as applied to Cepheids, it is important that we should know the time of decay of the fundamental pulsation and of its harmonics. The matter has been investigated by Edgar (*M.N.*, **93**, 422), who finds that, while the first harmonic is dissipated more rapidly than the

fundamental vibration, the time of decay of the latter is of the order of thousands of years only, when the usual law of opacity ($k \propto \rho/T^{\frac{7}{2}}$) is assumed. If the exponent of T in this relation can be reduced, the rate of dissipation can in certain cases be made much smaller.

Mira and other Late-type Variables.—Thermocouple measures have been made by Pettit and Nicholson (*loc. cit.*) of the radiation of 19 stars of spectral type Me and 2 stars of type Se, 6 at all phases, 5 at most phases and 10 on only a few nights. From the 11 stars best observed the mean radiometric range is $0^{m}.9$, the corresponding visual range is $5^{m}.3$, the average maximum and minimum temperatures deduced from water-cell absorption are 2350° and 1830° K.; the average diameters at maximum and minimum light are $0''.025$ and $0''.029$ and the mean absolute bolometric magnitude is $-3^{m}.2$. The coolest of these stars is χ Cygni, which varies between 2260° and 1630° K. The radiometric magnitude is brightest about 0·1 cycle after maximum visual brightness, while it is estimated that the real energy maximum (*i.e.* the maximum of the radiometric magnitudes after they have been corrected for absorption in the Earth's atmosphere) occurs 0·04 cycle later still. These phase relationships, and indeed all the results of measures of this nature, are complicated by the fact that a large part of the spectrum is broken up by molecular absorption bands, especially those of titanium oxide. On this account no temperature estimates were made from the differences between radiometric and visual magnitudes. This also is considered to be the reason for at least a part of the discrepancy found between the observed range of visual light and that computed from the temperatures given by the water-cell absorption. This discrepancy becomes worse when the variation of stellar diameter is taken into account. In the only case where spectroscopic observations are available, viz. *o* Ceti, the computed diameter variation agrees in amplitude with that from the radial velocity curve, but is almost exactly opposite in phase (*P.A.S.P.*, **45**, 194).

Four irregular variables of type M and 5 of type N were observed from time to time. The measured changes are generally too small for definite conclusions to be drawn with regard to variability, but it is thought that they are probably real for Betelgeuse (M2) and U Hydræ (N2). For V Cygni near minimum the water-cell absorption and heat index show a temperature of less than 1500° K. There are indications that N stars radiate more like black bodies than those of type M.

High-dispersion spectra of Betelgeuse, photographed during the years 1923–31, have been measured for radial velocity by Sanford (*Ap. J.*, **77**, 110). He confirms the period of variation, 5·781 years, deduced earlier by Spencer Jones, although he finds an amplitude 6·16 km./sec. as compared with 4·12. The variations are not perfectly regular. Maximum light occurs near maximum radius and *vice versa*, the radial velocity results agreeing with interferometer measures of radius as well as may be expected. If the star is pulsating as the radial velocities indicate, the effective temperature is at maximum 3430° and at minimum 2950°. There are no appreciable changes in the spectrum. Sanford (*P.A.S.P.*, **45**, 44) also has announced the presence of emission hydrogen lines in 7 stars of types R and N, 6 of which

are known to be variable. Radial velocities give for 6 of the stars a mean velocity difference, emission-absorption, of −25 km./sec., which agrees with other earlier work. Merrill, Sanford and Miss Burwell have classified a number of stars as N or S type, including a dozen recognised variables (*P.A.S.P.*, **45**, 306). At Mt. Wilson also, a comparison of the infra-red spectra of N stars with the electric furnace spectrum of carbon showed remarkable correspondence over hundreds of angstroms (*P.A.S.P.*, **45**, 278).

Plakidis (*M.N.*, **93**, 373) has demonstrated that the irregularities of the light curves of S Bootis and R Camelopardalis are of the nature of accidental fluctuations of period and of phase. The irregularities show no periodicity. In 19 long-period variables investigated by Lindley (*Journ. B.A.A.*, **43**, 125) irregularities of phase are greatest on the ascending part of the light curve. They are usually least after maximum.

It has been suggested that some of the phenomena of late-type variables might be due to condensation of gases in their atmospheres. This question has been discussed by Wildt (*Z.f.Ap.*, **6**, 345), who points out that the first substances likely to condense are the compounds of very high melting-points, such as *ScN*, Sc_4C_3, *TiN*, *TiC*, *ZrN*, *ZrC*, *VN* and *VC*. The condensations would probably occur in the form of finely divided particles, "aerosols," the stability of which is a difficult question. They would tend to form larger aggregates and to sink slowly until finally evaporated again. The velocity of descent is estimated as of the order of 0·9 km./hour. Wildt does not think that Merrill's suggestion of the alternate formation and dissolution of clouds of condensed matter is adequate in itself to explain the large amplitudes of long-period variables. He draws attention to the importance of the suggestion made by Miss Payne and ten Bruggencate that the formation of molecular absorption bands has a considerable influence on a star's light and colour.

Peculiar and other Stars.—Merrill (*Ap. J.*, **77**, 44) has described the spectra of AX Persei, RW Hydræ and CI Cygni, which have bright lines, including ionised helium, together with titanium oxide bands in absorption. These stars show resemblances to Z Andromedæ. The same author, with Miss Burwell (*ibid.*, **77**, 103), has given an account of the peculiar variations in the hydrogen lines of AB Aurigæ (R Coronæ type). The changes cannot be explained by orbital motion. The radial velocity of R Coronæ Borealis itself has been measured by Berman (*P.A.S.P.*, **45**, 55). There is no clear evidence for variability. The star was at normal brightness during the period covered by the observations. Guthnick (*Sitz. d. Preuss. Akad. d. Wiss.*, **24**, 724) has found that the variable Bailey No. 95 in the globular cluster M3 seems to be of R Coronæ type, which is abnormal for such a cluster. The minimum lasts about 54 days and the colour index is about 1·6.

Data concerning the radial velocity and spectrum changes in the RV Tauri variable, U Monocerotis, have been published by Sanford (*Ap. J.*, **77**, 120). The velocity of the centre of mass varies. The hydrogen lines are variable, being sometimes in emission, and titanium oxide bands are visible at certain phases.

It has been shown by Zessewitsch (*Bull. Leningrad Univ. Obs.*, **2**, 2)

that μ Cephei stars show two distinct periods superposed, between which there is a correlation. Variables with double periods have been discussed by O'Connell (*H.B.*, **893**, 14, 19), who also has shown a correlation between the two periods. The spectrum of the brighter component of HD 198287–8 shows complicated changes in radial velocity which have been analysed by Christie (*Ap. J.*, **78**, 200) into two periods of 18·60 days and about 12·3 years. There is variable hydrogen emission and changes in other line intensities. The light curve is of the β Lyræ type. A. de Sitter has given observations of RZ Cassiopeiæ (*B.A.N.*, **7**, 119), another star which shows changes which may be analysed into two very distinct periods. The longer period here is attributed to a third body.

Several well-known stars have been shown to be variable in one way or another. Struve and Roach have announced a variable bright $H\alpha$ line in α Cygni and in Rigel (*Ap. J.*, **77**, 226; **78**, 302). The emission lines of γ Cassiopeiæ are variable, according to Lockyer (*M.N.*, **93**, 362, 619), with a suggested periodicity of about 4 years. Struve has examined the width of $H\alpha$ in this star and concluded that it probably does not vary by a large amount (*Ap. J.*, **77**, 66). Interferometer measures of the diameter of α Scorpii by Pease gave recently $0''{\cdot}029$, while the value in 1921 was $0''{\cdot}040$. The difference is thought to be real (*P.A.S.P.*, **45**, 275).

Spectra with variable line intensities have been studied by Morgan (*Ap. J.*, **77**, 77, 226) and by Miss Westgate (*ibid.*, **77**, 227). Edwards (*M.N.*, **93**, 729) has observed the β Canis Minoris star 42 Camelopardalis and found alterations of line intensities with a period of about $0^{d}{\cdot}1385$. The ratio of emission lines to absorption lines in the Be variable 52 Aquarii shows a close correlation with radial velocity according to McLaughlin (*Ap. J.*, **77**, 221).

The short-period variable BD $41^{\circ}1044$ has been investigated by Hopmann (*Z.f.Ap.*, **6**, 385). It shows a large change of colour index during its period, which is $0^{d}{\cdot}0989$. R. O. R.

Double Stars

The first list of double stars found by Dr. R. A. Rossiter at the Lamont-Hussey Observatory at Bloemfontein is published in pt. ii of vol. lxv of the *R.A.S. Memoirs*. In about five years' observing with the 27-inch refractor 2350 new double stars were found. The search was carried to magnitude 9·5 of the *Cape Photographic Durchmusterung* and 9·3 of the *Cordoba Durchmusterung*. The volume gives data for 2232 stars, viz. *C.P.D.* number, R.A. and Dec. for 1900, position-angle to the nearest degree, separation to $0''{\cdot}1$ and the magnitudes. Most of the stars are between Dec. -25° and -65°. On the whole the stars are fainter than double stars found visually (except perhaps those found by Mr. Espin and Mr. Milburn), although not fainter than those of many lists depending on photography. Pairs have only been retained if the separation has been under a definite value depending on the magnitude, approximately $5''{\cdot}0$ to magnitude 9·0, $4''{\cdot}0$ to magnitude 9·5, $3''{\cdot}2$ to magnitude 10·0, and $2''{\cdot}0$ to

magnitude 11·0. The list contains a large number of difficult double stars which will be practically beyond the reach of all telescopes except the large visual refractors at Bloemfontein and Johannesburg. The scale of magnitudes is not stated, but it obviously makes the stars fainter than given in *C.P.D.* or *Co. D.*

B.A.N., 241, contains the eleventh list of new double stars observed by Dr. van den Bos at Johannesburg. It contains the new double stars B1903 to B2060 and also gives a description of 384 wider and fainter pairs. The same observer in *Union Observatory Circular*, 90, gives 1462 measures of 354 previously known double stars. Most of these are close double stars, some of them very close. The same circular gives a short description by W. S. Finsen of an interferometer fitted to the eye end of the Johannesburg refractor, together with measures of 11 double stars with a separation of the order of 0″·15. [Attention is drawn to the extraordinary accuracy with which suitable close pairs have been measured with this instrument. See also p. 313.—*Secretaries.*]

B.A.N., 253, contains 825 measures of 226 double stars made by Dr. G. P. Kuiper with the 10½-inch refractor of the Leiden Observatory. The stars were selected as (1) showing orbital motion, (2) having a large parallax, (3) neglected in the past.

Dr. P. Baize and Mme. Igounet give continuations of their measures of double stars in *Journal des Observateurs*, **16**, 49 and 183. The first list contains separate measures for 93 stars, the second the yearly means for 200 stars, mostly Σ, OΣ or β.

A. N. Vyssotsky, in *A.J.*, 997, gives measures of the position of the companion of Sirius derived from photographs taken with an objective grating. The deduced magnitude of the companion (*Ap. J.*, **78**, 1) is 7·1 as compared with the previously accepted value of 8·44.

The study of double stars to be found from the measures of astrographic plates has been continued. In *A.N.*, **250**, 49, S. G. Barton gives details for 923 double stars in the Cape Zones −40° to −52°. Of these 133 were previously catalogued. There is also a list of 310 suspected doubles. Mr. Bhaskaran, in *Journal des Observateurs*, **16**, 140, gives a list of 23 old and 15 new double stars found in Hyderabad Astrographic Zones.

Dr. Luyten, in *M.N.*, **93**, 196, gives data for 102 pairs of faint stars of common proper motion in the southern sky. These pairs must be physically connected.

Other lists of measures of double stars are :

Observer	Reference	No. of Stars	Notes
Bemporad, A.	*A.N.*, **248**, 29	40	Catania Zone +48° to +54°
Doberck, W.	*A.N.*, **248**, 187	67	Σ, etc.
Espin, T. E., and Milburn, W.	*M.N.*, **93**, 192	32	New Es.
		68	New M.
		22	Old
Leonard, F. C.	*L.O.B.*, 450	53	24 New

A new binary star is announced by Aitken, *P.A.S.P.*, **45**, 261.

Orbits.—The following tables indicate new orbits which have been determined together with the values of the principal elements.

Astronomical Circular, No. 10, of Tashkent Observatory, gives the following determinations by N. Voronov :—

Number in ADS	Period Years	*a*	*e*
		"	
3711	284·9	1·40	0·24
8148	183·3	1·92	0·65
8337	82·0	0·42	0·52
9578	165·0	1·02	0·58
11334	284·7	0·35	0·12
11989	167·2	1·19	0·19
15267	92·4	0·33	0·22
Sirius AB	50·24	7·51	0·587
„ BC	2·81	1·37	0·46

Union Observatory Circular, 90, contains the following, all by Dr. van den Bos, except the last, by Finsen :—

	Period Years	*a*	*e*
		"	
Σ 98 = ADS 3711	524	1·748	0·446
Brs. O 5	233·5	4·047	0·536
β 456 = ADS 8239	437	0·990	0·633
Σ 2737 = ADS 14499	101·4	0·656	0·702
Ho 296 = ADS 16173	21·62	0·312	0·610
β 744 = ADS 3159	84·20	0·528	0·622
Σ 2052 = ADS 10075	217·1	2·198	0·751

Additional orbit determinations are :

Computer	Reference	Star	*P* Years	*a*	*e*
				"	
Aitken, R. G.	*P.A.S.P.*, **45**, 190	β 1077	43	0·6	0·3
Arnam, R. N. van	*A.J.*, 1000	Σ 2	275	0·715	0·57
Dawson, B. H.	*A.J.*, 994	δ 31	4·56	0·173	0·30
Luyten, A. J.	*P.A.S.P.*, **45**, 183	OΣ 4	108	0·41	0·543
„	*A.J.*, 990	Castor	340	5·84	0·43
„	*Ap. J.*, **78**, 225	13 Ceti	6·91	0·244	0·73
Volet, Ch.	*Journ. des Obs.*, **16**, 107	Σ 60	478·7	11·92	0·495
„	„ „ **16**, 107	Σ 186	158·4	1·00	0·69
„	„ „ **16**, 138	Castor	286·3	5·91	0·616
Wilson, R. H.	*A.J.*, 998	Σ 2294	184·27	0·534	0·906

Attention should be drawn to the remarkably short period of δ 31, which is the brighter component of β 1000. In *P.A.S.P.*, **45**, 90, Aitken has drawn attention to the binary β 314, which appears to have an orbit plane containing the line of sight. Miss M. W. Makemson has investigated the multiple system of ζ Cancri in *A.J.*, 788, and given orbits for AB, AB–C*c*, and C*c*; AB being the close pair, C the fainter component of the wide double and *c* an invisible companion to C.

Miscellaneous.—Dr. Kuiper of Leiden, now at Lick, has made a statistical discussion of double stars, published in Dutch as a dissertation. It will be published in English in an extended form in the *Annals* of Leiden Observatory. A note on it by Dr. Oort is given in *The Observatory*, **56**, 337. Amongst the problems discussed is the distribution of major axes (or periods) in an attempt to solve the question whether the various classes of double stars (as observed) belong to a continuous series or not. Another problem is the frequency curve of difference of magnitude of the components.

In *C.R.*, **196**, 253, D. Barbier deals with the mean factor in deriving dynamical parallaxes, and in *A.J.*, 996, the same author deals with further formulæ for the deduction of dynamical parallaxes, but these can have very rare application.

In *U.O.C.*, 90, Finsen has investigated the position of orbit places in space for 28 double stars, but finds no definite concentration of the poles. In the same circular van den Bos shows that the two similar neighbouring stars Σ 1398 and Σ 1400 have often been confused. Both stars show relative motion of components—for the second pair at least the motion is orbital. J. J.

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Talence, Observatoire
Tashkent, Astronomical Observatory
Tiflis, Stalin Bau-Institut der S.S.R. Georgien
Tokyo, Hydrographic Department of the Imperial Japanese Navy
Tokyo, National Research Council of Japan
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ADDRESS

Delivered by the President, Professor F. J. M. Stratton, on International Co-operation in Astronomy: A Chapter of Astronomical History.

At a season when the difficulties of international co-operation are being daily laid before us, when the nations of the world are adopting more and more a separatist policy, it may not be amiss to consider for a short time the history of common action among the peoples of the world in the field of astronomical observation and research. Science is by nature truly international. It knows no boundaries, no distinction of nationality nor of race. The work of the investigator in London is placed freely at the disposal of his colleagues in Leningrad or California, while he builds up his investigation on a foundation laid in Paris or Tokyo. In this sense, in the free exchange of knowledge and of theories, astronomy shares in the general freedom of science from national limitations. In a certain sense, however, astronomy is especially an international science: no one observatory can examine the whole of the sky; no single observer can keep a continuous watch on the varying activities of a celestial body like the Sun or a Nova. The fullest knowledge of the stellar universe can only be obtained by a world-wide network of co-operating individuals and institutions. I had intended originally to limit myself to an account of the activities of the International Astronomical Union; but they are so closely connected with earlier co-operative movements in astronomy that to appreciate them fully one must go back through a whole chapter of astronomical history. The question where to start was happily answered for me on turning up p. 1 of vol. i of our *Monthly Notices*, where I read that to the Annual Meeting of the Society on 1827 February 9 the Council reported as follows :—

"In the last report of the Council it was stated that a letter had been received from M. Bessel relative to a plan for a general survey of the heavens and for making detailed charts of the same. The *prospectus* relative to this subject was translated and distributed, not only amongst the members of this Society, but also amongst such other astronomers as might be supposed desirous of encouraging so useful and important an undertaking. Two applications were made from this country to the Committee at Berlin, appointed to superintend the distribution of the allotments; but it is doubtful whether more than *one* of them can be apportioned here, as it is understood that the rest have been, or probably will be, taken up by different astronomers on the continent."

This scheme for a survey of stars down to the tenth magnitude originated with Bessel in 1824; he published it when it became clear that the similar scheme, notified in the address drawn up in 1820 by Sir John Herschel (*Mem. R.A.S.*, 1, 4) on the motives and objects of our Society, was not

likely to mature. Bessel's scheme was warmly encouraged by the Berlin Academy; a grant of money was made towards the expenses and a committee was appointed to organise the work. The 24 hours of right ascension were allotted to a number of different observers, including Bessel, Struve and Argelander. It was hoped that the whole scheme would be completed by 1828, but by that date only for 3 of the 24 hours were the chart and catalogue completed—let me add that the only one allotted to an English observer, the Rev. T. J. Hussey of Chislehurst, was one of these three.

The scheme was to have been completed by *1828*: here is a passage from our Council's report in *1859* February:

"The year 1858 saw the conclusion of the series of star-charts published by the Academy of Berlin. Distinguished as are the names of the contributors to this celebrated work, the retrospect of the undertaking can hardly be regarded as encouraging to those who look to great results from voluntary co-operation. Thirty years have elapsed since their commencement, and many a chart has had to be transferred to other hands than those which were pledged to its performance. A fair estimate of the time necessary for work thus apportioned would be three years for the observation and five for the observation and publication, yet thirty have really been required."

The moral of this lesson might have been taken to heart by a later generation, thus warned against entering into a plan of co-operation on too large a scale. Programmes extending over many years in a department of astronomy, where experience is limited, are liable to many dangers; not the least of these is that before they are finished a better, more accurate and more economical method may be developed for accomplishing the same results.

It is, however, to the credit of these early charts that they gained for Berlin the honour of the first recognition of *Neptune*, and that they greatly promoted the search for minor planets. Argelander's famous *Bonner Durchmusterung* was well under way before the completion of the earlier scheme. The Council report from which I have quoted above adds that Argelander "has for some time expressed the wish that some countryman of ours with '*Englische Geld und Englische Kraft*' will undertake a similar survey of the southern hemisphere." This in due course was done not by one of our countrymen but by the vigour, persistence and skill of an American astronomer, Benjamin Gould, supported by the gold of the Argentine Government.

Before leaving the subject of stellar charts mention must be made of the well-known A.G. zone catalogues for the northern sky, one of the earliest of many schemes of international value and interest carried out by the Astronomische Gesellschaft. The latitude zones were distributed in 1869 by arrangement between the Vorstand of the Gesellschaft and the observatories concerned; the earliest zone catalogues to appear were those of Albany, Christiania and Helsingfors published in 1890.

But this is anticipating our story, and I turn back to the year 1832 when, in connection with the award of the King of Denmark's medal for the discovery of a telescopic comet, the first scheme was drawn up for the organised

circulation of astronomical news. Announcement of discovery had to be sent to Professor Schumacher, the editor of the *Astronomische Nachrichten*. Three years later the scheme was modified : for Great Britain or any other quarter of the globe except Europe, notice had to be sent to Francis Baily ; he and Schumacher undertook to communicate to each other immediately any information they received relative to the discovery of comets. Schumacher continued to act as a channel between the astronomers of the Continent and those of Great Britain and America until his death in 1850. During the quarrel between Holstein and Denmark the existence of his observatory at Altona was in doubt. The astronomers throughout the world rallied for the protection of Schumacher, and almost every civilised country made through its representatives urgent appeals to the Danish Court that the observatory and its respected director should be spared and protected. Lord Palmerston, pressed to action by the Council of this Society, obtained assurances from the Danish Government that neither the Professor nor his establishment should be affected. This may be regarded as a valuable instance of international co-operation in astronomy not too remote from the circumstances of our own day to be mentioned here.

At a later date, 1869, the Imperial Academy of Sciences at Vienna offered prizes for a series of years for cometary discoveries ; telegrams had to be sent to Vienna for distribution to the principal observatories. Through the Smithsonian Institution in 1873 an arrangement was made for free transmission between Europe and America of cable telegrams announcing astronomical discoveries requiring co-operative observations. Nowadays it is the Astronomical Society of the Pacific which through its Donohoe medal encourages the discoverer of the unexpected comet, but the distribution of the news is arranged for otherwise. In 1879 at the meeting of the Astronomische Gesellschaft attention was drawn to the need for an improved telegraphic service for news of astronomical discoveries. Professor Förster in 1881 July sketched in the *Astronomische Nachrichten* a possible organisation ; and his scheme, which at first seemed unlikely to be carried out, was brought to the front again after the failure of the existing means of communication to give general news in time of the Great Comet of 1882 September. A committee of eight, nominated by Förster, took charge of a European central office for astronomical telegrams established at Kiel under Professor Krueger.

Again we must step back to record an event of international importance in astronomy—the foundation of the Astronomische Gesellschaft at Heidelberg in 1863. Though primarily German, this body has always been alive to the value of international co-operation in astronomy. Its statutes specifically stated that its membership was not bounded by nationality, and the list of those attending its first meeting includes members present from ten countries. Its zone catalogues have already been mentioned. Since 1870 it has published annually ephemerides of variable stars, and it has an agreed control over their nomenclature. Since 1881 it has assumed a share in the control of the *Astronomische Nachrichten*, and it has supported financially and otherwise the *Astronomischer Jahresbericht* since its foundation in 1898. For all

these services to astronomy we have good reason to express our indebtedness to the Astronomische Gesellschaft.

Selenography must next claim our attention. The completion of Schmidt's great map of the Moon after 34 years of work was notified in our Council's report of 1874; the Observatory of Athens, of which Schmidt was Director, had no funds for its publication, but five years later the map was published at the cost of the German Government on the instigation of the German Crown Prince; it was, in fact, photolithographed at the General Staff Office under the direction of Count von Moltke. In 1907 a Committee on Lunar Nomenclature, and consisting of Franz, Loewy, Newcomb, Saunder, Turner and Weiss, was appointed by the International Association of Academies.

A different method of securing international co-operation is to be seen in the action of the committee of American astronomers appointed by the American Association in 1870 for the purpose of selecting a series of standards of stellar magnitudes. This committee at once asked the Councils of the Astronomische Gesellschaft and of our Society for their co-operation, and three classes of magnitude—brighter than $6^{m}.0$, $6^{m}.0$ to $10^{m}.0$, and fainter than 10^{m},—were allotted to the three bodies concerned.

In all the co-operative schemes so far discussed, though the work was distributed among different countries, yet the initiative came from some society and from some individual, who took the responsibility of working out the scheme and arranging for a committee of control. No international scheme in which the different countries concerned acted through their own delegates had so far been worked out. It was unfortunate that the first attempt to bring together an international conference to work along these lines in a subject allied to astronomy was a failure. It was to have met in Paris in 1870 to discuss the adoption of international standards, but was spoilt by the Franco-Prussian War. However, in 1875 representatives of 20 states met in Paris at the invitation of the French Government for what became known as the Conférence Diplomatique du Mètre. At this meeting there was founded the Bureau International des Poids et Mesures, placed at the Pavillon de Breteuil; from the research work carried on there and the decisions of subsequent conferences held at Paris, standards in many branches of physical science have been adopted by the scientific world: the mere mention of the value of g and the invention of invar will remind you how closely geodesy was concerned with the work of this bureau, and that leads me naturally to the meeting of the International Geodetic Association held at Rome in 1883 October: at this meeting the delegates from 15 states recommended the adoption for world purposes of the Greenwich meridian. On 1884 October 1, on the invitation of the President of the United States, a conference of delegates from 27 states met at Washington, and adopted as the single prime meridian for all nations the meridian passing through the centre of the transit instrument at the Royal Observatory of Greenwich. The jubilee of the Greenwich meridian is due for celebration this year.

The success of the Washington Conference of 1884 may well have

inspired the next big move. The development of photographic methods had led a number of astronomers to think that the time had come for securing as complete a map as possible of the whole heavens. Admiral Mouchez, Director of the Observatory of Paris, being assured of wide agreement took the initiative, and at his request the Académie des Sciences sent out fifty invitations to foreign academies and to directors of observatories of 16 countries to meet at Paris in 1887 April. At this meeting a Permanent Commission was set up charged with carrying forward the project of a Carte du Ciel: at the meeting of the full congress at which the Commission was appointed, Gill made the characteristic remark that the most important point was that the Commission should commence its work on the following morning—which it did. A small bureau with executive powers was appointed for detailed decisions, and every few years the Permanent Commission met in Paris: at the later meetings a number of other astronomers not closely connected with the work of the Carte du Ciel were invited to attend. A number of allied questions of considerable importance were discussed, such as photographic magnitudes, the polar sequence, the objective grating and the observation of Eros at the opposition of 1901. For this work special committees were appointed to supervise the organisation of observations of Eros and of the comparison stars. At the conference of the Permanent Commission in 1896 Tisseraud stated that the success of this catalogue of over 2,000,000 stars was assured. Forty years later it is still impossible to repeat these words with confidence, but we can look back on much valuable work done not only on the main scheme but in connection with the many important side-issues which arose from the work.

Küstner's discovery of the variation of latitude led to the appointment of a commission in 1893 and to the creation of a central bureau at Potsdam in 1895, under the International Geodetic Association; a scheme was developed for observations at a number of stations in different longitudes but on the same parallel of latitude. These were in working order by the autumn of 1899.

An event of a different type, but of great general importance to astronomy, was the starting in 1895 of the *Astrophysical Journal* with a strong international Board of Associate Editors to assist the American editors, Hale and Keeler. Certain standards were adopted for use in the journal (and were recommended by your Council among others for general adoption), *e.g.* the Rowland scale of wave-lengths with a tenth-metre as unit, the nomenclature $H\alpha$, $H\beta$, $H\gamma$ for the Balmer series, and the printing of maps of spectra red to right.

Next in order of date comes the important international conference on Fundamental Stars, held at Paris in 1896, immediately after a meeting of the Permanent Commission of the Carte du Ciel. This arose largely from the needs of the Carte du Ciel, and followed correspondence between the Directors of the National Ephemerides. To Newcomb was entrusted the revision of the *Nautical Almanac* constants and the preparation of a provisional catalogue of Fundamental Stars. A similar meeting was held in Paris in 1911 when the Directors of the National Ephemerides met a number

of leading observational astronomers to secure by co-operation a greatly increased list of daily star ephemerides ; the intermediary stars of Backlund and Hough were added to the Fundamental Stars of Auwers, Newcomb and Boss. The work was divided amongst the various almanacs and other allocations of work were agreed to : thus the Germans continued their long-established calculations on minor planets, the Rechen-Institut collaborating with the Astronomische Gesellschaft ; the Americans took over the reductions of eclipse and occultation phenomena ; and the French and British calculated the ephemerides of the Sun, Moon and Planets, using in some cases, by agreement, different tables.

Leaving on one side for the moment the formation of the International Solar Union, we come next to Kapteyn's Plan of Selected Areas, a scheme put forward in 1904 by the Director of the Astronomical Laboratory at Groningen with the cordial support of numerous colleagues. The object was to get well-distributed data of every possible kind for the fainter stars. In 1910 the committee in charge of the scheme were Kapteyn, Gill, E. C. Pickering, Hale, Küstner, Dyson and Adams.

The last of the series of conferences which made Paris for so long the centre for international work in astronomy was held in 1912 October to deal with the question of wireless time-signals. As was first suggested by the International Association of Academies in 1906, it was decided to create a Commission Internationale de l'Heure. A bureau was founded at Paris, the home of the Eiffel Tower signals ; a *Bulletin Horaire* was agreed upon giving corrections and an ultimate detailed discussion of the time-signals and of their recording at various stations : memoirs on radiotelegraphy, instruments, methods of emitting and receiving signals were to be published, the necessary funds to be found by the adhering countries on a population basis. The convention governing all these details was never ratified owing to the outbreak of war.

Last of the pre-war institutions, but far from being the least important, was the International Solar Union. In 1904 the Committee on Solar Research of the National Academy of Sciences approached various societies and academies asking them (1) to appoint committees to initiate and organise co-operation in solar research, and also (2) to send representatives to attend a meeting at St. Louis in 1904 September. At that gathering the International Solar Union was formed to aid and suggest, without in any way interfering with personal liberty, wherever it could be of service, and to collect information for discussion. A small executive committee of Hale, Schuster and Arrhenius was appointed. Briefly summarising the work that the Union initiated and carried out at and between its successive meetings at Oxford, Meudon, Mt. Wilson and Bonn, one may say that it performed for solar physics and astrophysics what the Permanent Commission of the Carte du Ciel had so long been doing for the astronomy of position. It acted as a focus for co-operative work, which before its foundation had been limited in solar physics to two fields—the sunspot number determination at Zürich under Wolf and Wolfer with the collaboration of many scattered observers, and the prominence observations published by the Spettroscopisti

Italiani at Catania from data secured at Rome, Odessa, Kalocsa and Zürich.

Under the Union committees were appointed to work at and report on the measurement of solar radiation, the fixing of standards of wave-length, the spectra of sunspots, the spectroscopic determination of solar rotation, and co-ordination of eclipse programmes and of researches with the spectro-heliograph. Later a committee was appointed to consider and report on stellar classification, and to establish a system that could be recommended for permanent and universal adoption. The volumes of the *Transactions* of the Union contain many valuable reports on these subjects. The expense of printing these volumes—or rather the loss on the printing and sale—was at first borne privately, but at the meeting at Bonn a method of financing the publications by subscriptions from those attending the meetings was discussed. This was to have been settled at Rome, to which city the Union at the close of the Bonn meeting confidently accepted an invitation for 1916.

And then came the World-War!

This is not the place nor the time to discuss the ethics of warfare. All that we are concerned with to-day is the fact that so far as international astronomical co-operation is concerned it is an unmixed evil. For the time being co-operation between many of the countries, whose activities I have referred to, became impossible ; even when the war was over, the bitter feelings it left behind precluded in many cases easy co-operation for some years between those of the opposing sides. Faced with the virtual impossibility of returning at once to an all-inclusive scheme, the leading men of science of the allied countries met at Brussels in 1919 July to set in motion, so far as they could, the wheels of international co-operation. The International Research Council and its various constituent unions were then and there formed. In the continued activities of Schuster and Hall we may find the link which bound the International Astronomical Union to the past. We are concerned to-day only with the history of this Union. Granted the difficulties and limitations under which the work was done, I would record my conviction that the astronomical world is greatly indebted to those astronomers who drew up the general lines of organisation of the Union. I remember hearing more than one of those who had travelled to Brussels express disappointment that so much business and so little astronomy was done there. It is my hope to-day to convince you of the value to astronomy of that business.

With M. B. Baillaud (to-day one of two survivors of the 1887 Paris conference) as President, and with Professor Alfred Fowler as General Secretary, the Union commenced its work by organising 32 standing commissions to deal with separate branches of astronomical work. The general scheme was very much along the lines of the Solar Union with one important exception—an income was secured by contributions from the adhering organisations which represented the various countries. In addition to inheriting most of the work previously organised by the Permanent Commission of the Carte du Ciel and by the Solar Union, the new body also accepted the charge of the Bureau Internationale de l'Heure, which M.

Baillaud had kept in being since 1913. The subvention required for this bureau demanded a large proportion of the income for which the Union first budgeted.

The neutral countries—at this date this grouping of the nations sounds strange, but it was tragically real in 1919—were at once invited to join the Union, and by 1922, when the Union held its first meeting in Rome, 19 countries were adhering or about to adhere to the Union. Now, of course, there is no restriction with regard to nations adhering to the Union. Of the committees which reported to the Rome meeting, no fewer than 14 may be regarded as successors to bodies whose pre-war activities have already been referred to, 5 committees carried on alongside similar bodies still working in countries not adhering to the Union, and 13 took over questions which had hitherto lain outside any scheme of international co-operation. The casual way in which, as we have seen, the early schemes were mostly started left many gaps which a careful survey had shown worthy of attention. In giving a brief account of the more important tasks that the Union has accomplished under the rule successively of Baillaud, Campbell, de Sitter, Dyson and Schlesinger, it may be well to start with the newer subjects.

A central bureau for double stars has been set up at the Lick Observatory with the support of the Union, a general card catalogue of double-star measures has been prepared and is kept up to date at the bureau, and lists of standard binaries have been drawn up for the study of systematic errors of individual observers. A standard notation and details as to the observational data to be generally published have been adopted. The Committee on Radial Velocities have drawn up, by agreement among the chief workers in the subject, lists of standard velocity stars and of wave-lengths for use in spectral classes O, B and A. With the aid of a grant from the Union, Galle's *Cometenbahn* was continued from 1893 to 1922 by the British Astronomical Association, who were also invited by the Union to co-operate with the Students' Observatory at Berkeley in computing orbits and ephemerides of periodic comets. The Committee on Notations produced three-letter and four-letter abbreviations of the names of constellations for use in tabular work. They have also suggested the use of a unified notation of symbols, some of which have been generally adopted. Further, through the energy of M. Delporte they have published an atlas giving formal boundaries to the constellations: these new boundaries were carefully chosen so that no change of name would be involved for variable stars nor for stars in the old catalogues and lists. This subject of the boundaries of the constellations was raised first by the British Association and discussed by your Council in 1838! A useful star atlas has also been published by this committee, and a list of observatories, instruments and staffs was produced by the Royal Observatory at Uccle with the aid of a grant from the Union. Further important agreements were come to as to the nomenclature for time to be used when the diurnal zero hour changed to midnight at the beginning of 1925; the continuance of noon for the zero of the Julian day was also decided by the Union, and an agreement come to that for catalogues, other than those of precision, the equinox of 1900·0 should be retained in use

until the time came for a change to that of 2000·0. The other work of the committees of the Union in this group has lain mainly in co-ordinating and standardising the work of observers, in producing valuable reports on the work in progress or completed, in interchanging information among workers in a common field, and in discussing the most important tasks calling for action. The Committee on Calendar Reform did not present its report to the General Assembly at the Rome meeting and were not re-elected; the subject has recently been taken up by a committee of the Astronomische Gesellschaft. Several committees, feeling that their work did not lend itself to organised co-operation, have been dissolved at their own request. New committees, on the other hand, have been formed to deal with subjects that are developing, such as stellar statistics, spectrophotometry and the constitution of the stars. For the last-named committee the Union made a grant towards the expense of printing tables of solutions of Emden's equation.

Two of the new committees—solar parallax and selected areas—belong to the other groups into which the committees of the Union have been divided. We now consider the committees working alongside other bodies. The Bureau for Astronomical Telegrams placed at first at Uccle under Professor Lecointe was transferred in 1922 to Copenhagen under Professor Strömgren. Of essential importance were the friendly relations maintained with the old Centralstelle at Kiel under Dr. Kobold. In the ten years 1922–32 the bureau distributed 1998 telegrams and 381 circulars. It is partly maintained by a grant from the Union. The Committee on Bibliography are proposing to bridge the gap between the *Bibliographie Générale* of Houzeau and Lancaster and the beginning of the *Astronomischer Jahresbericht*. They are also supporting the supplementary early brief bibliography published by the Lyons Observatory. Valuable bibliographical suggestions have also been brought forward by this committee. The Committee on Variable Stars have published a list of Cepheid variables for co-operative photographic study, and lists of stars for which further series of observations are desired. They have also taken up actively the question of sequences for variable star comparisons. Annual ephemerides of eclipsing variables are published at Cracow with the financial support of the Union, which also helped towards the cost of publishing a volume of observations by members of the British Astronomical Association. The Committee on Minor Planets, working in co-operation with the Rechen-Institut in Berlin, have made many useful recommendations on notation and on the details of publication of observations and ephemerides. The work of supervising and reducing the observations of the northern latitude stations was undertaken by a bureau at Mizusawa under Dr. Kimura. Results have been published annually and the detailed reduction of the observations is now in hand. Work has also now been extended to the southern hemisphere. Financial help was given towards the publication of the earlier observations of the Internationale Breitendienst. The bureau at Mizusawa is financially supported both by the International Astronomical Union and by the International Geodetic and Geophysical Union. It is under the charge of a joint committee of the two Unions.

Similar arrangements have now been made between the two Unions for the Bureau de l'Heure. The Time Commission inherited a large intergovernmental scheme, but with much reduced power and authority, limited mainly to astronomical and geodetic interests. These it has served by the establishment of a time laboratory in connection with the Paris Observatory, by the publication of circulars for information and of research memoirs and by maintaining the service of scientific time-signals. The bureau has been charged with the reduction of the observations of the world network of wireless time-signals carried out last autumn under the auspices of the Committee on Longitudes. This was a repetition of the scheme initiated by the Bureau of Longitudes in 1921, supported by the Union and carried out successfully in 1926 with the aid of 32 participating observatories.

The Commission de l'Heure was the heir of a pre-existing body. So are the committees which remain for brief mention. The Committee on Ephemerides are in a sense heir to the Congrès International des Ephémérides Astronomiques of 1911, or rather to the unofficial or advisory part of that gathering. They act as a centre for the meeting of directors of the national ephemerides and as a means of securing co-operation with the observing astronomers. The Committee on Lunar Nomenclature have prepared a collated list of formations; also of amendments to Miss Blagg's list, which was published in 1913 with the aid of a grant from the Paris Académie des Sciences. A grant has been made by the Union for the printing of these new lists.

No fewer than seven committees succeeded to the work of the International Solar Union. The Committee on Stellar Classification have modified and elaborated the scheme of the Draper Catalogue to meet the requirements of the present day, and have extended numerical subdivisions at both ends of the sequence. The Committee on Wave-lengths have prepared lists of standard lines, primary, secondary and tertiary standards mostly of iron, but also of other elements such as neon and trypton. A list of solar standards has also been given, and important decisions of a technical nature have been taken with regard to experimental procedure. The Committee on Solar Physics arranged for various centres for the collection of statistical data of solar phenomena. At their suggestion the International Research Council set up a committee for the study of the relationships between solar and terrestrial phenomena. This committee have brought out three valuable reports, and every quarter they publish a *Bulletin* giving daily character figures of solar phenomena. The Union has supported this work with a grant towards the publication of data for earlier years; it has also made grants for the printing by the Paris-Meudon Observatory of *Cartes Synoptiques de la Chromosphère solaire*, and by the Arcetri Observatory of *Immagini Spettroscopiche del Bordo Solare*, compiled from observations at Catania, Madrid and Zürich—a continuation of the earlier work of the Spettroscopisti Italiani. The Eclipse Committee undertake to keep intending observers in touch with each other's plans and programmes and with the conditions of observation along the belt of totality, so far as information is made available to the committee.

Lastly, we come to the committees which represent the work of the Permanent Commission of the Carte du Ciel. The study of Eros at its opposition in 1931 was entrusted to a committee of the Union ; various grants have been made for expenses of computation and printing. The Committee on Stellar Photometry have published a series of valuable reports indicating the complexity and difficulties of the subject. Dr. Seares has been President of this committee throughout, the only other individual to retain his presidency unchanged since 1919 being Dr. Kimura. The Committee on Meridian Astronomy, in addition to securing co-operation in the observation of the star lists suggested by the Conference on Fundamental Stars, have initiated other schemes of common work, *e.g.* the observation of reference stars for the determination of proper motions of faint stars in Kapteyn's Selected Areas, and the re-observation by photography of the A.G. zones, with the co-operation of the Astronomische Gesellschaft. This committee also urged the reduction of Hornsby's observations, carried out by Dr. Jackson and Dr. Knox-Shaw, and it helped with substantial grants an expedition to the equator from the Leiden Observatory for a study of the declinations of northern and southern fundamental stars. The committee of the Carte du Ciel have continued the task, rendered difficult by the stress of financial conditions in every country, of bringing the work to completion. The last report gave 116 zones out of 181 as the number for which the publication of rectangular co-ordinates had been completed. Grants have been made to meet the expense of printing volumes undertaken as an extra task by certain observatories, replacing others which have failed to carry out their share of the work.

Recently the Committee on Selected Areas has been reconstituted as a committee of the Union. This only became possible after the revision of the statutes in 1931 had given the valuable privilege to the committees of the Union to co-opt members from countries not adhering to the Union. Full use has been made generally of this power to the advantage of the work of the Union, and it has proved of especial importance in times of financial stress, which have led several countries to withdraw from the Union.

And here I come to the most difficult problem facing the Union to-day —how to maintain its activities without losing the support of countries which are struggling with financial crises. At its last meeting the Union passed a resolution that it was more important to reduce the rate of subscription than to risk the loss of further adhering countries by making increased grants. The reasons which underlay that resolution have by no means disappeared ; if anything they have become intensified. The way of economy is not easy, but it must be faced ; it is to be hoped that with care retrenchment may take place without undue hardship to individuals or dislocation to work in hand.

The help that the Union has given to astronomical research has not been merely financial, though even in that field it has been substantial—grants of over £14,000 have been made to its various committees, and over £2000 has been spent in the printing, publication and free distribution to individuals and observatories of its volumes. By the valuable reports of the presidents

of its committees, by the stimulus to workers in special fields from the opportunities of meeting their colleagues to discuss their own and allied problems, by the suggestions made as to work required to be done and as to the best way of getting it done by mutual effort—in a thousand and one ways the Union has proved a steady source of inspiration and help. To its founders and its first general secretary, Professor Alfred Fowler, who placed and kept it on the right lines, our science is greatly indebted. It behoves their successors to see to it that the organism which they have created is kept alive, responsive to new needs and changing conditions, a powerful support of astronomy in all its branches, and a centre of co-operative goodwill among the astronomers of the whole world.

ELECTION OF OFFICERS AND COUNCIL

The following Fellows were elected as Officers and Council for the ensuing year:—

President

F. J. M. Stratton, Esq., D.S.O., O.B.E., M.A., T.D., D.L., Professor of Astrophysics, Cambridge.

Vice-Presidents

Sir Arthur S. Eddington, M.A., D.Sc., LL.D., F.R.S., Plumian Professor of Astronomy, Cambridge.

John Evershed, Esq., C.I.E., F.R.S.

H. Spencer Jones, Esq., M.A., Sc.D., F.R.S., Astronomer Royal.

Major W. J. S. Lockyer, M.A., Ph.D., Director of the Norman Lockyer Observatory.

Treasurer

J. H. Reynolds, Esq., M.Sc.

Secretaries

W. M. H. Greaves, Esq., M.A.

W. M. Smart, Esq., M.A., D.Sc., John Couch Adams Astronomer, Cambridge.

Foreign Secretary

Alfred Fowler, Esq., D.Sc., F.R.S., Yarrow Research Professor of the Royal Society, Imperial College of Science and Technology, South Kensington.

Council

S. Chapman, Esq., M.A., D.Sc., F.R.S., Chief Professor of Mathematics, Imperial College of Science and Technology, South Kensington.

C. R. Davidson, Esq., F.R.S.

H. Dingle, Esq., D.Sc., Assistant Professor of Astrophysics, Imperial College of Science and Technology, South Kensington.

Sir Frank W. Dyson, K.B.E., M.A., D.Sc., LL.D., F.R.S.

F. J. Hargreaves, Esq.

H. F. Newall, Esq., M.A., D.Sc., F.R.S., Emeritus Professor of Astrophysics, Cambridge.

B. M. Peek, Esq., M.A.

Rev. T. E. R. Phillips, M.A.

H. H. Plaskett, Esq., M.A., Savilian Professor of Astronomy, Oxford.

R. O. Redman, Esq., M.A., Ph.D.

W. H. Steavenson, Esq.

R. Stoneley, Esq., M.A., Sc.D.